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MR. GOLDWIN SMITH ON "THE DATA OF ETHICS."

By W. D. LE SUEUR, B. A.

"Because we must not dream, we need not then despair."
—MATTHEW ARNOLD, *in Empedocles on Etna.*

MUCH instruction has been drawn from the story of Naaman, the Syrian, who, when he went to the prophet Elisha, to be healed of his disease, expected that the man of God would "do some great thing," and was greatly discouraged and offended when he merely recommended him to go through a strenuous course of ablution in the most convenient stream. There is one application, however, of the narrative which we do not remember to have seen made, and yet which is undoubtedly important. The prophet of olden times is represented to-day by the philosopher, who also leads a life of retirement and severe contemplation. And just as the contemporaries of the prophet insisted on investing him with magical powers, while they undervalued his real gifts of practical sagacity and spiritual insight, so do the men of to-day demand of the philosopher to "do some great thing," while they scorn the demonstration he offers that the truth has neither to be brought down from heaven nor up from hell, but is very nigh them—in their hearts and on their lips. Such errors are to be expected on the part of the multitude; but there are men who, from their general breadth of view and clearness of perception, might be expected to do justice to a scheme of philosophy just in proportion to its avoidance of extravagant pretensions, just in proportion as its author had visibly aimed at learning from nature rather than imposing upon nature his own preconceptions. Of the class of men to whom we refer, no higher example could be found than Mr. Goldwin Smith: of the kind of philosophy to which we refer, no better type could be found than that of Mr. Herbert Spencer.

And yet, unless our own judgment is fatally at fault, Mr. Smith, one of the very best-furnished critics of modern times, has signally failed to do justice to Mr. Spencer's philosophy, or at least to the portion of it embodied in his last volume but one, "The Data of Ethics." The article contributed by Mr. Smith to the "Contemporary Review" for February of this year constitutes the most serious attack, by far, that has been made upon the volume in question. To mention Mr. Smith as its author is to vouch for the force, perspicuity, and felicity of the style, and for a large infusion of that common-sense philosophy which carries persuasion to the general reader. Many have read that article who never read "The Data of Ethics"; and we have little doubt that the opinion of these in regard to the questions at issue has been largely molded by it. In these days of rapid literary production it is a rare thing to find an article remembered three months after it is written; but Mr. Smith's article still finds echoes in many quarters of society, and particularly from the pulpit. It can not, therefore, be considered too late to submit it to a careful examination, in order to see how far Mr. Spencer's positions have really been shaken by the arguments brought against them.

Mr. Spencer's book is essentially a study of human conduct (purposive action) in its origin and development, with a view to discovering the nature and sanctions of morality. That it is of the utmost importance that men should feel strongly the distinction between right and wrong Mr. Spencer everywhere implies; and his object is to place that distinction on a basis which, if not so imposing as that heretofore furnished by theology, may at least not be subject to the vicissitudes which seem to be the portion of all theological codes. We must presume our readers to be more or less familiar with the work in question, and to have followed Mr. Spencer in his demonstration that, as purpose takes a wider range, it gathers to itself an accompaniment of moral emotion. In connection even with self-regarding actions, a certain sense of moral power accompanies every subordination of an immediate impulse to one more remote. The individual awakens to a sense of the capacity for *choice*, and the foundations are thus laid for moral freedom. It is, however, the life of the family, the tribe, the community, that lends the greatest enlargement to individual thought and feeling. Care for offspring comes first to break down the tyranny of exclusive regard for self. The family develops into the tribe, and men learn to practice a certain measure of justice toward one another as the essential condition of co-operation. The increasing harmony of outward relations has its inward counterpart in increased strength and breadth of sympathy. The moral quality of an action depends upon the degree in which it tends to promote or diminish happiness; but this, as Mr. Spencer repeatedly points out, is in most cases to be determined rather by the conformity or non-conformity of the action with certain general principles ascertained to be favorable to happiness.

than by an inquiry into the results likely to flow from it in a special case. Moral actions, in general, are those favorable to life, not only to its preservation, but to its improvement; immoral actions are those which tend to the shortening or to the impoverishing of life. In speaking of life here, we speak not only of the condition of animation, but of all that successive experiences, successive enlargements of the range of thought, action, and sympathy, have built into, or worked into, the human consciousness. To help forward this work of integration is good; to retard or counteract it is evil. In common speech the terms good and evil are upon the whole applied to actions just in accordance as they tend, or are believed to tend, in one or other of these directions.

As the aim of all voluntary action is the furtherance of happiness, the test of perfection in an action will be its fully accomplishing that object. A man who procures a momentary gratification by some unwholesome indulgence has not performed, even from a selfish point of view, a perfect action, seeing that its effects are partly, at least, destructive of the end he has in view. The man who, losing his temper, quarrels with a neighbor, does not, even from a selfish point of view, perform a perfect action; for, whatever satisfaction he may derive at the moment from the utterance of angry words, he can derive no benefit, but only the reverse, from the subsequent alienation of his neighbor's feelings. From a social point of view, no action is perfect which benefits only the actor, or which benefits some one else at the actor's expense. Self-sacrifice may be ethically noble; but that any necessity for it should arise implies some defect in the conditions of existence, and therefore of action. If it enables us, on the one hand, to estimate the moral resources of humanity, it points, on the other, to evils which it behooves us to remedy; for why, we ask, should the gain of one be purchased by the loss of another? To find a perfect action, therefore, we must look for one all the effects of which, so far as they can be traced, are good, which not only involves no sacrifice of happiness, either to the actor or to the person who is the object of the action, but which is equally beneficial to both. Social evolution being a manifestly unfinished process, the region of the social activities can not be expected to furnish the best examples of perfect adjustment. In searching for such an example, Mr. Spencer therefore falls back, in the first place, on the physical region, and cites —to Mr. Smith's great amusement and scorn—the case of a mother suckling her child. We quote his words:

> Consider the relation of a healthy mother to a healthy infant. Between the two there exists a mutual dependence which is a source of pleasure to both. In yielding its natural food to the child, the mother receives gratification; and to the child there comes the satisfaction of appetite—a satisfaction which accompanies furtherance of life, growth, and enjoyment. Let the relation be suspended, and on both sides there is suffering. The mother experiences both

bodily pain and mental pain; and the painful sensation borne by the child brings, as its results, physical mischief and some damage to the emotional nature. Thus the act is one that is to both exclusively pleasurable, while abstention entails pain on both; and it is consequently of the kind we here call absolutely right.

Here we are asked to recognize the *reductio ad absurdum* of Mr. Spencer's whole system of ethics. For our own part, we wholly fail to see where the absurdity comes in. If what we are in search of is a type to which *all* actions might advantageously conform, where, we ask, shall a better be found than this? What would the condition of society be if all the actions of men conformed to this type, blessing alike the doers and those toward whom the actions were directed? There is but one answer: it would be perfect. The end of all ethical self-discipline, the end of all social adjustments, is precisely to bring things as nearly as possible to this consummation. The good man, in the highest sense of the word, is he who loves his neighbor as himself; in other words, who desires that his action shall benefit his neighbor equally with himself, and not one neighbor only, but all neighbors, and who, therefore, regulates his actions with a view to universal utility. And in all social reforms what is it that we desire to bring about but this—that one man's gain shall not be another man's loss, but that the gain of one shall be the gain of all?

Mr. Smith places in contrast with the typical action chosen by Mr. Spencer the case of an Italian physician who courted the infection of a deadly plague in order that he might, for the benefit of his stricken fellow-citizens, the better understand and describe its symptoms and development. But is that the type to which we should wish *all* human actions to conform? That there should be such actions, we must, in the first place, have plagues; and in order that we may have plagues we must have ignorance and filth. Would it really be worth while to order these things, to the end that one Italian physician might, by an act of sublime self-sacrifice, shed one ray of light athwart the general gloom?

Mr. Smith says that, according to Mr. Spencer, "the action of the Italian physician . . . is ethically inferior to that of a Caffre woman suckling her child." This, however, is misleading. Though Mr. Smith speaks of *actions*, the contrast which his words suggest is between *motives*. When we want to estimate the quality of an action in relation solely to the doer, motive is everything; but, when we desire to estimate its intrinsic value as a link in the net-work of human activity, motive must be left out of sight. The motives of the Inquisitors were, we may presume, good, but their deeds were diabolical. The motive in this case was of the highest possible order; but, when the act was completed, a noble life had been sacrificed. How can an act which inwraps so much of irreparable loss be classed as perfect?

More important still is it to remark that Mr. Spencer distinctly assigns the action which he cites to a lower plane altogether than that to which the action of the Italian physician properly belongs. These are the words with which he introduces his illustration: "Among the best examples of absolutely right actions to be named are those arising where the nature and the requirements have been molded to one another *before social evolution began.*" (The italics are ours.) The adaptation found subsisting between mother and child was established in a pre-social period; and, though social evolution has since been carried forward many stages, the relation in question retains its character as an almost wholly physical one. No doubt maternal love is to-day a much tenderer and more complex thing than in savage days; but, as the higher affection is not always guided by adequate knowledge, we must still look to the physical adaptation as the highest example of perfect adjustment. The action of the mother nourishing her child is "absolutely right," but "absolutely right" in a comparatively low sphere of conduct; the action of the Italian physician is only "relatively right," but it is "relatively right" in a much higher sphere of conduct. It is, therefore, not correct to say, without careful qualification, that, according to Mr. Spencer's philosophy, "the action of the Italian physician is ethically inferior to that of a Caffre woman suckling her child." What may be said of it is that it is *typically* inferior, although ethically higher; that is to say, less adapted to serve as the type of perfect action, though indicating the presence of far superior moral elements. The distinction is not difficult to seize.

The precise position from which Mr. Smith makes his attack on Mr. Spencer is not very easy to discern. He evidently does not like the evolution philosophy in its application to morals; and yet it is not very clear that he takes his stand distinctly on any other. A most critical time, he thinks, has arrived in the intellectual development of society, and what the result is going to be he does not venture to predict. Serious breaches have been made in the defenses, not only of revealed, but of natural religion; the theistic hypothesis itself is threatened. The breaches *may* be repaired—Mr. Smith does not feel at all certain one way or the other; but meanwhile he thinks it a safe thing to point out the deficiencies of the evolution philosophy as compared with a theistic philosophy. But supposing the breaches should *not* be repaired, but, on the contrary, widened; and supposing we should have in the end to fall back on the evolution philosophy or something like it, would it not then be the part of wisdom to make the most of it—to show it in the most favorable, rather than in the least favorable, light? Mr. Smith seems to us to be somewhat in the position of a man battering a house in which, according to his own admission, he may some day have to live. Supposing the evolution philosophy to be true, or to be an adumbration of the truth, any de-

fects we may discover in it are simply defects in the constitution of things as compared with our former conceptions on the subject; and finding fault with the constitution of things is not the most profitable of employments.

Among the objections brought by Mr. Smith against a naturalistic morality, the following seem to be the principal:

1. It would not favor such acts of devotion as are now prompted by "the ideas and hopes" of religion.

2. It can not explain to us why a man surrounded with all imaginable worldly comforts, but with a murder on his conscience, is unhappy, while a man who gives his life for others is happy in the act.

3. It can not attach any meaning to such words as "the sacredness of human life."

4. It furnishes no basis for moral approval or condemnation.

Let us attempt to deal with these objections in the order in which they stand:

1. In regard to acts of devotion, it will be observed that Mr. Smith speaks somewhat hesitatingly. Referring to the manning of a life-boat for some perilous enterprise, he asks if we are "sure" that the men would not be less ready to take an oar were they told that death would make "an end for ever of them and of their connections with those whom they loved." Well, we are *not* sure what the effect would be of a sudden and most untimely announcement of that character; but that does not really seem to us to be the question. The question, if we mistake not, is, whether, if the ideas contained in "The Data of Ethics" prevailed in the world, it would be possible to maintain a life-boat service at all; and we should like to ask Mr. Smith whether *he* is sure that it would not. If he is uncertain upon this point, his uncertainty may perhaps balance ours upon the other. Our own opinion, which must pass for what it is worth, is, that it would be quite possible. The foundations of devotion lie very deep in human nature. That poor Caffre mother we were speaking of a moment ago would illustrate it if the need arose. Every nation and every tribe has had its heroes who cheerfully faced death for the common cause; and that without a thought of future reward, or, in a multitude of cases, any definite expectation of continued existence. Describing one of the very worst periods of Roman history, Tacitus is yet able to say, "*Contumax etiam adversus tormenta servorum fides*" (slaves were found who braved even torture for the sake of their masters). Yet these unhappy bondmen had no "village church" to serve as the center of ideas and hopes relating to another sphere of existence. If we may attempt an explanation of the matter in terms of the evolution philosophy, we should say that the course of physical evolution creates in us a strong attachment to life, but that the course of what Mr. Spencer has called super-organic evolution gradually creates for us objects of thought and affection which may become dearer than life

itself. Our hope, therefore, is that, in the society of the future, not only will "the milkman go his rounds"—a point upon which Mr. Smith kindly reassures us, and, after all, one of no little significance—but volunteers for the life-boat, the fire-brigade, and all necessary heroic undertakings, will still be forthcoming. If, when the time arrives, men have ceased to risk their lives, as they now so frequently do, in foolish enterprises, without, so far as one can judge, being particularly incited thereto by ideas or hopes connected with the village church, it will be all the better.

2. Evolutionary ethics can not explain conscience, can not tell us why the bad man is miserable in prosperity, and the good man happy in adversity. Is it really so? What is human character but a complex of mental and moral habits, every habit incorporated into it becoming a more or less imperative voice vibrating through the man's whole nature? To know that you have not dotted an *i* or crossed a *t* will sometimes give you an uncomfortable feeling. Make a rule of anything, and you will not depart from it without uneasiness. How powerful are the habits of the body every one knows, and those of the mind are not less so. The murderer referred to by Mr. Smith is ill at ease because he has allowed a momentary impulse connected with the least authoritative* part of his nature, the mere desire for personal advantage, to carry him into an act of rebellion against a principle of conduct woven into his nature long before he was born, and for which in his subsequent life he has constantly been compelled, not only to profess, but to demand, respect. If it be said that it is impossible to account on this theory for the tone of absolute authority with which conscience urges its decrees, we would ask for a very careful consideration of the passages quoted below from the "Data of Ethics." Mr. Spencer has well shown that, just in proportion as the reasons for doing, or refraining from, a particular act are dissociated from what we may call the ultimate material inducements or deterrents, will the *authority* they possess be greater. When a man eats because he is hungry, he feels the power, but not the authority, of appetite. When, on the other hand, he refrains from a vicious indulgence because its later effects will be bad, or when he takes a walk before breakfast because he believes it will conduce to his health, though its good effects may not be immediately apparent, he recognizes and feels the *authority* of sanitary rules. In these cases the degree of dissociation between the rule or principle recognized by the mind and the actual facts on which it rests is but slight; yet the rise of *authority* is plainly visible.

* Let the reader who needs to do so refresh his memory with the following passages from Spencer, "Data of Ethics," chapter vii—"The Psychological View": "From the first, complication of sentiency has accompanied better and more numerous adjustments of acts to ends. . . . Whence it follows that the acts characterized by the more complex motives and the more involved thoughts have all along been of higher authority for guidance. . . . When, led by his acquisitiveness, the thief takes another man's property,

A rule of conduct once established, the mind, working quite independently of the will of the individual, resents any attempt to impugn its authority. Naturally enough, seeing that, to impugn its authority means an unsettlement of all that the rule had settled. Take the case now in question. We can not conceive the existence of any social order, unless the principle is recognized that no man should, for selfish purposes of his own, take the life of another. But, let a man be so overmastered by his cupidity as to commit this crime, he can not by that one act of rebellion undo the work already accomplished in his mind, by virtue of which he had learned to condemn murder on principle. It is to his interest now to deny the principle, but he can not do it without tearing his own mind to pieces; for not more truly have certain elements been compounded in his body, to form its various organic substances, than have elementary experiences combined in his mind to form those principles of thought which sustain its functional activity and make it a living organism. And just as the true unit of the body is not any elementary atom, but a cell, so the true unit of the mind is not an isolated experience, or any cluster of unorganized experiences, but a combination of experiences, a generalization from experiences.

The murderer in the case supposed by Mr. Smith has eluded the law, and not only paid no material penalty whatever, but actually reaped vast benefits from his crime. Could any case be possibly imagined in which—making, of course, allowance for the inferiority of nature of a man who could commit murder at all—the violated authority of perhaps the most fundamental of all social principles should make itself more keenly felt? Had the man been caught red-handed, and come promptly under the sentence of justice, his remorse would have been slight in all probability; possibly he might not have felt any. But, escaping as he did, and prospering by his crime, his mind would remain continually open to the upbraidings of that part of his nature which he had outraged by his deed, to all the *reasons* which the experiences of every day as well as his involuntary thoughts would suggest why the deed should not have been done. Is not this enough? Must we still call in the Eumenides before

his act is determined by certain imagined proximate pleasures of relatively simple kinds, rather than by less clearly-imagined possible pains that are more remote and of relatively involved kinds. . . . Throughout the ascent from low creatures up to man, and from the lowest types of man up to the highest, self-preservation has been increased by the subordination of simple excitations to compound excitations—the subjection of immediate sensations to the ideas of sensations to come—the overruling of presentative feelings by representative feelings, and of representative feelings by *re*-representative feelings. As life has advanced, the accompanying sentiency has become increasingly ideal; and, among feelings produced by the compounding of ideas, the highest, and those which have evolved latest, are the re-compounded or doubly ideal. Hence it follows that as guides the feelings have authorities proportionate to the degrees in which they are removed by their complexity and ideality from simple sensations and appetites."

we can understand why the murderer should be wretched amid his wealth?

We must not, however, forget that Mr. Smith supposes the murderer to be able to flatter himself that he has probably caused more happiness than unhappiness by his crime. Such a supposition might perhaps embarrass a utilitarian of the old school, but hardly an adherent of the "rational utilitarianism" taught by Mr. Spencer. Crude utilitarianism assumes that an action can only be judged by the consequences which directly and visibly flow from it; rational utilitarianism says that the criterion of an action is some rule of conduct established by experience. The crude utilitarian is like a man who would discard or ignore the multiplication-table, and insist on doing all sums involving multiplication by addition; or who should insist on working out, by tedious and uncertain arithmetical processes, problems which could be solved with the far greater ease and certainly by algebra. Experience shows what *lines* of conduct, what *principles* of action, are favorable to happiness in general, and to the satisfaction of the instinct of sympathy in particular; and human civilization can not be carried very far before the principle is established that harm must come from the shedding of human blood. Such a principle gains *authority* over men's minds; and, when an action is done that conflicts with it, it is in vain that the perpetrator tries, by a fresh calculation of all the supposed elements of the case, to show that his particular crime may be all right.

3. We are probably now prepared to estimate the force of the next objection urged by Mr. Smith against evolutionary ethics, that they do away with the idea of the "indefeasible sacredness of human life." They would no doubt do away with any surplusage of mere sentiment on the subject; but, seeing that the first moral principle which emerges, from the evolutionary point of view, is equity, and seeing that life is what every man holds most dear, it is very hard to understand why a system, which may be said simply to rationalize the Golden Rule, should lead men to deal less carefully with human life than the systems of the past. What light does history shed upon the question? In what estimation was human life or human suffering held in the ages of faith? It was surely in a pre-evolution period that a man could be hanged in England for stealing a sheep. Such things can not be done to-day. Why? Is it—we should like a candid answer to the question—because there is a deeper impression than formerly that man is made in the image of God; or because the sentiment of justice has grown stronger, and men have learned to sympathize more with one another?

4. Finally, we are told that Mr. Spencer, being an evolutionist, must be a necessarian, and that, as such, it is not open to him to condemn any act as wrong, seeing that the doer of the act could plead that his conduct was just what the point he had reached in evolution ren-

dered natural and necessary. Mr. Spencer is undoubtedly an evolutionist, but we do not know that there is any distinct warrant for saying he is a necessarian. We do not know that he is more embarrassed by the secular antithesis of free-will and necessity than others have been before him, or are now. Were necessarianism a corollary from evolution, it would be in order to remark that it has also been, with a not uninfluential school of Christian thinkers, a corollary of the conception of the divine nature. Mr. Smith, we observe, records his own objection to the term "free-will"; remarking that what has inappropriately passed under that name should rather be defined as "the difference given us by consciousness between moral and physical causation. He thus recognizes moral causation; and his objection to the expression "free-will" would seem to be grounded on its implied denial of such causation. Mr. Spencer, on his side, objects to the free-will theory because it denies the "cohesions" which demonstrably exist between psychical states. Is it certain that between the two views so great a gulf is fixed that Mr. Smith can afford to snap his fingers in happy security, while contemplating the speculative torments of the author of "The Data of Ethics"? Seeing, however, that this is a difficulty with which human thought has never been able to grapple successfully, it might be as well to raise no question concerning it. The evolutionist condemns a wrong action on this ground, that it conflicts with some principle of proved utility, or of proved equity—the two are really one—which, if not as potent so might be desired, still has its place in the mind of the man who has neglected or overridden it. We condemn moral inconsistency just as we do intellectual inconsistency. When a man puts forward an opinion we regard as false, our only hope of persuading him that it is false is by bringing into the strongest possible relief some truth or opinion, *accepted by him*, with which the opinion in question conflicts. Precisely parallel is the procedure when a man performs an act of which we disapprove: we call some ethical principle accepted by himself, and acted upon at times by himself, to bear witness against what he has done. By doing so we re-enforce the higher principle, and perhaps bring about shame and repentance for the improper act.

We have thus tried to deal with the chief objections formulated by Mr. Smith against the evolutionary theory of morals. To speak of that theory as a purely "physical" one (as Mr. Smith does) is hardly correct. Mind, according to Mr. Spencer, is made up of feelings and relations among feelings, and these are not properly physical. Memory and judgment may have a physical basis, but they are not themselves physical. The evolution of conduct, according to Mr. Spencer, depends wholly upon accretions of capital, so to speak, in consciousness. A dim and narrow consciousness renders possible only a most imperfect self-direction; a clear and highly developed consciousness, on the other hand, gives a correspondingly increased power of self-

direction, which is used in the furtherance of life and happiness. There is a school of French philosophers to-day * who, while making frank profession of atheism, speak of man as the union of an organism with an "immateriality." The language is uncouth ; but it might be used, at least provisionally, to express Mr. Spencer's conception ; for, while the whole direction of every human being proceeds from his consciousness, that consciousness is not itself material or physical, the very essence of materiality being objectivity to sense. From the evolutionary point of view every mite of moral effort is just as precious as from the theological point of view ; but what the evolutionary theory does not do is to reconcile us to the miseries that have abounded and still abound in the world, as possibly having their explanation and justification in some supernatural scheme of government. If the sufferings borne by our fellow-creatures are any part of the Divine scheme, as Mr. Smith hints may perhaps be the case, what confidence can we feel that we are right in trying to alleviate them ? With a strange inconsistency, the partisans of a supernatural view of disease are always ready to apply themselves most vigorously to abbreviating by natural means the chastisements which they say are meant for their good ; while the more sensible among them manage, by a careful attention to the rules of health, to escape such chastisements altogether, or nearly so. And so we have no doubt it would be if Mr. Smith had it in his power to greatly ameliorate the general lot of mankind : he would do it, and let the moral education of the race take its chance under the happier conditions.

Evolutionary ethics tell us what is evil, and explain the why. They tell us that whatever depresses the energies of any human being, or comes between labor and its due reward, is evil. It drops no hints of mysterious compensation hereafter for ills borne in this life—so making things a trifle more comfortable still for the "man in the suburban villa, with a good business in the city," whom the voice of duty so imperiously calls to take a regular luncheon every day, instead of merely swallowing a hasty sandwich. That worthy citizen might, in the interest of his digestion, like to think that the shivering, storm-tossed mariner, the delver in the mine, the overworked and underfed farm-laborer, and all the beaten and baffled and despairing ones whose lot is so disagreeable a contrast to his own, should some day, after they had served their turn here in the production of capital, have some modicum of compensating happiness dealt out to them in a better world. If such be his soothing fancy, he can not at least profess to draw it from the doctrine of evolution, which proclaims, without reserve or qualification, that suffering is suffering, that injustice is injustice, and that, if we would remedy these, we must work while it is called day. It is the weakness not the strength of theological and ultra-mundane doctrines

* The so-called "Socialistes Rationnels," whose organ, "La Philosophie de l'Avenir," contains some acute and powerful writing.

that they lead, and have led, men to regard with more or less of acquiescence the sufferings of "this present evil time." That there may be a Providence inwrapping the whole of human life with its environment, and that there may be, to higher faculties than ours, a significance in life that we have never grasped, it would be most adventurous and, indeed, unphilosophical to deny. Admitting such a possibility, however, or even probability, our duty is in no way changed. The whole solar system may be hurrying on through space toward some unknown goal, or in some infinite and incalculable circuit; but the motions that concern us are those that take place within the solar system, that lend themselves to observation and calculation, and that affect more or less the conditions of human life. We live in an environment to which we are adapted: absolute truth lies beyond us, but relative truth is within our grasp. The poet says that "things are not what they seem," but things *are* (to us) what they seem. What else can they be? And it is our duty to deal with them as we find them, with a constant view to the realizing of higher and higher harmonies in life. Some notes we have already attuned, but there are discords yet, many and harsh, to be subdued. Then let us set our faces steadfastly forward, not to "confront a void," for there is no void to confront—nothing has fallen out of the universe that ever was in it—but with a determination to conquer more and more of moral freedom, and, by our conscious efforts, to aid that unconscious labor of the ages by which better and better conditions are ever being won for the human race.

TIME-KEEPING IN LONDON.

By EDMUND A. ENGLER,
WASHINGTON UNIVERSITY, ST. LOUIS, MISSOURI.

I.

IT is proposed in this paper to describe some special features of the instruments by which time is kept at the Royal Observatory, Greenwich, the means for correcting them, and the methods and instruments by which time-signals are distributed from the observatory to London and elsewhere.

The primary standard time-keeper of England is a sidereal clock kept in the basement of the Royal Observatory, Greenwich. This clock is of the best construction, and is, moreover, provided with the most approved apparatus for compensation and correction.

Experience has shown that the best results are obtained when the connection between the driving-weight and the pendulum of a clock is as slight as possible. This has been accomplished in the Greenwich clock by the use of an elegant escapement, the details of which are

shown in Fig. 1,* representing a back view of the clock-train. The crutch-axis, supported by the arm (*c*) and the back plate (*b*) of the clock-train, carries an arm (*e*), attached at *f* to the left-hand pallet arm. The pallets are carried by the crutch-rod (*d*). At *g* is attached a detent projecting toward the left and ending in a light curved

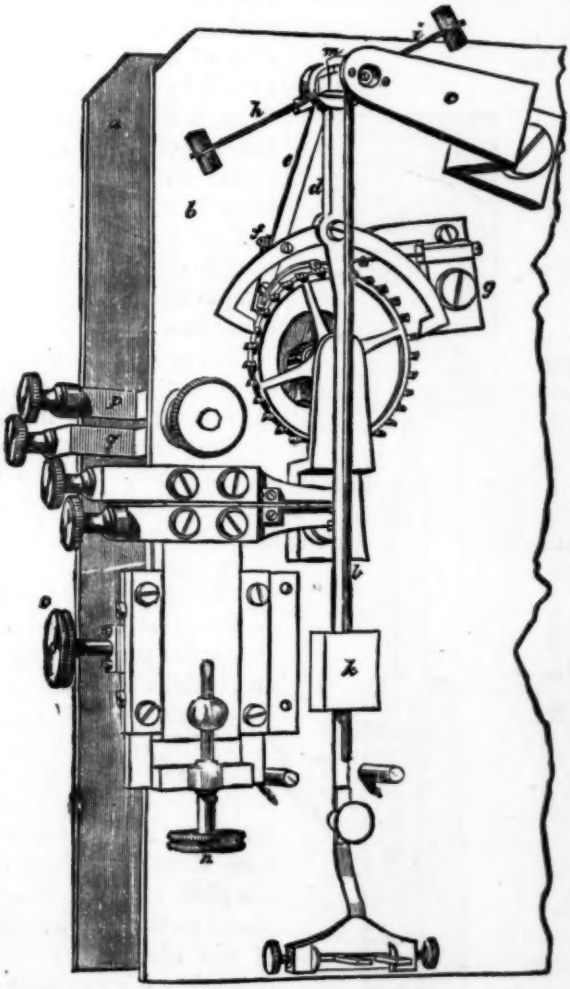

FIG. 1.—GREENWICH CLOCK ESCAPEMENT.

spring. Near the top of the escape-wheel this detent carries a jeweled pin which locks the wheel. The action is as follows: When the pendulum swings toward the left, the arm (*e*) lifts the delicate spring at the end of the detent, the wheel is released and drops forward so that a tooth presses against the face of the pallet and gives an im-

* Figs. 1, 3, 4, 5, and 6, have been taken from Lockyer's "Stargazing," through the courtesy of Macmillan & Co., London, publishers, by permission of the author.

pulse to the pendulum; the spring at the end of the detent immediately locks the wheel again, and the pendulum swings on freely to the left. When the pendulum swings to the right, the light spring at the end of the detent lets it pass without unlocking the wheel. The right-hand pallet is only intended to catch the wheel in case of accident and forms no essential part of the escapement. Thus, it will be seen, the pendulum is quite free except during a part of every alternate second, when it releases the escapement and receives an impulse; the seconds-hand, attached to the escape-wheel, moves only once every two seconds.

FIG. 2.—GREENWICH PENDULUM. ELEVATION.

FIG. 3.—GREENWICH PENDULUM. SECTION.

The most important source of error in the running of a fine clock is the change in the length of the pendulum due to change of temperature. Two methods suggest themselves of eliminating this error: 1. To put the clock where it will not be subject to changes of temperature. 2. To counteract the effect of changes of temperature. To this end various kinds of pendulums have been devised, notably the mercurial and gridiron forms, which are known under the general name of "compensating pendulums." At Greenwich the two methods are combined to insure complete success. The clock is placed in the magnetic basement of the observatory, where the temperature is as nearly uniform as possible, and apparatus is provided to annul the effect of any change of temperature which might occur.

Tests made with a mercurial pendulum disclosed the fact that the steel rod responded more quickly than the mercury to a change of temperature, and that consequently

an appreciable interval of time was required for perfect compensation; a modification of the gridiron form, shown in Fig. 2, was therefore adopted. The pendulum was designed by Messrs. E. Dent & Co., of London, for the Transit of Venus Expedition (1874), but has since been used for the primary standard time-keeper of the United Kingdom. Its construction will be best understood by reference to the section shown in Fig. 3. To the lower end of a steel rod, suspended in the ordinary manner, is attached the screw for rating the pendulum. On this screw and surrounding the rod rests a zinc tube, extending upward; inclosing the zinc tube and attached to its top is a steel tube extending downward; on a collar, at the lower end of the steel tube, hangs the cylindrical leaden bob, attached at its center. Slots and holes are cut in the tubes in order to equally expose all parts. The following table, taken from the official records of the Royal Observatory, is published by Messrs. E. Dent & Co., for the purpose of showing the performance of a clock with steel and zinc pendulum:

CLOCK—DENT 1914.

DATE.			Clock slow of Greenwich sidereal time.		Mean daily losing rate during each interval.	Average temperature of external air.
	Days.	Hours.	Minutes.	Seconds.	Seconds.	
1871—September	3	21.....	14	31·8	..	..
	17	21.....	15	34·1	4·4	62°
	24	21.....	16	2·3	4·0	54
October	1	22.....	16	34·2	4·5	50
	8	21.....	17	5·1	4·4	52
	15	21.....	17	36·9	4·5	46
	22	21.....	18	8·2	4·5	54
	29	21.....	18	37·8	4·2	47
November	5	22.....	19	7·8	4·3	47
	12	22.....	19	36·2	4·1	39
	19	21.....	20	5·8	4·3	35
	26	22.....	20	36·3	4·3	34
December	3	21.....	21	6·7	4·4	36
	10	22.....	21	33·9	3·9	30
	17	21.....	22	6·6	4·7	40
	26	0.....	22	45·2	4·8	42
	31	22.....	23	13·2	4·7	43
1872—January	7	22.....	23	46·3	4·8	42
	14	21.....	24	20·7	4·9	40
	21	21.....	24	54·2	4·8	39
	28	22.....	25	30·2	5.1	42
February	4	22.....	26	6·4	5·2	44
	11	22.....	26	41·4	5·0	47
	18	21.....	27	16·0	5·0	44
	25	22.....	27	50·0	4·8	45
March	3	21.....	28	24·1	4·9	46
	10	22.....	28	58·1	4·5	49
	17	21.....	29	31·2	4·8	45

During the whole time of rating, the clock was situated in a small hut erected for observing the Transit of Venus. No record of the temperature of the hut was kept, but the variations would be very

similar to those of the external air, whose average temperature for each interval is given in the table.

The compensating action of the pendulum evidently depends upon the relative lengths of steel and zinc, and it is easily possible that great difficulty would be experienced in cutting and fitting tubes of exactly the right length; to complete the adjustment a very delicate contrivance is added.

Two compound bars of brass and steel (*h* and *i*, Fig. 1), with small weights at their ends, are hung to the crutch-axis by means of a collar loose enough to be easily turned. The rods are so made that under normal conditions the brass and steel are of the same length, and the two bars are in the same straight line; the center of gravity of the rods and the weights (regarded as one body) is therefore in the axis, and the weights are balanced in every position, no matter what angle the line of the rods makes with the plane of the horizon; they affect the pendulum only by their inertia. But, when a change in temperature occurs, the brass and steel become of unequal length, owing to a difference in the co-efficients of expansion of the two metals, the rods are bent, and the center of gravity of the rods and weights is no longer in the axis, nor is it in the same vertical plane as the axis except when the weights are in a horizontal line; so that an unbalanced force is introduced whose compensating action varies from a maximum when the weights are in a horizontal line, to zero when the weights are in a vertical line. To be explicit, suppose the rods to be horizontal and the brass uppermost, and let there be an increase of temperature. The brass will expand more than the steel, and, the rods being bent downward, the weights will be lowered. As the pendulum swings the weights swing with it, and are continually trying to get back to a horizontal position where they would balance each other; if they were swinging alone, they would evidently swing faster than the pendulum, and therefore, being attached, they accelerate its motion. If the steel were uppermost, the weights would be raised with an increase of temperature and the pendulum retarded. If the rods were both vertical, a change of temperature would only throw the center of gravity of the two weights to one side or the other of the axis, but would not raise or lower it; this would only introduce a continuous force tending to make the pendulum oscillate farther on one side than the other, but not affecting its rate. At intermediate positions between the vertical and horizontal, the change in the position of the center of gravity due to a change of temperature would vary with the angle made by the line joining the centers of gravity of the two weights with the plane of the horizon; any required compensating action, between the limits above mentioned, for a known change of temperature, can therefore be obtained by setting the rods at the proper angle.

In order to make a small change in the rate without stopping the pendulum, the device shown in Fig. 1 has been employed: A weight

(*k*) slides freely on the crutch-rod shown back of it in the figure, but is held by the screw on the end of the spindle (*l*) which hangs from the nut (*m*) at the crutch-axis. By turning the nut (*m*) the weight (*k*) can be lowered or raised, and this makes the clock gain or lose.

But the nicety of the correction of variations due to changes of temperature has brought to light variations due to another cause commonly quite overlooked ; it has been found that the pendulum is affected by changes of barometric pressure. A change in the barometer of an inch and a half will sensibly alter the rate of the pendulum. The difficulty might be avoided by placing the clock in a vacuum, but this is evidently impracticable. In the Greenwich clock the method shown in Fig. 4 has been adopted to counteract the effects

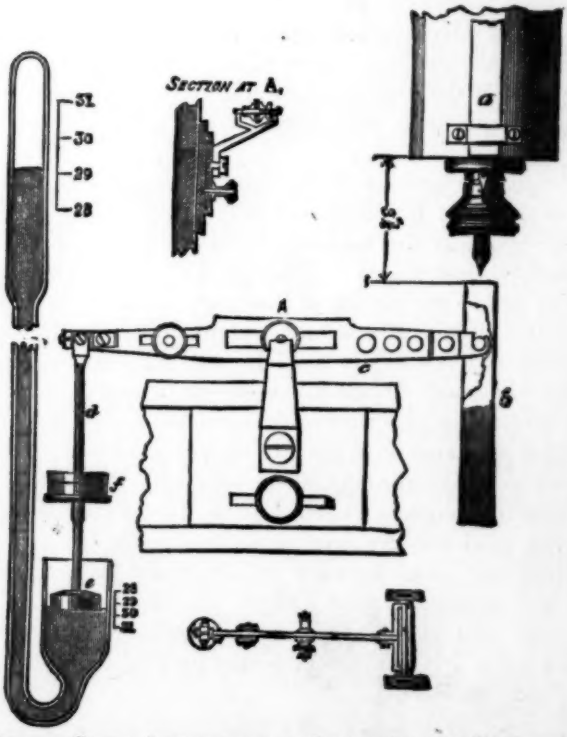

FIG. 4.—GREENWICH CLOCK : ARRANGEMENT FOR COMPENSATION FOR BAROMETRIC PRESSURE.

of barometric changes. To the pendulum-bob are attached two vertical bar-magnets, one in front (*a*) with the north pole down, the other at the back (and therefore not shown in the figure), with the south pole down. Below these and normally at a distance of $3\frac{3}{4}$ inches from them is a horseshoe magnet (*b*) which hangs on one end of a lever (*c*) nicely balanced on knife-edges at A ; the other end of the lever (*c*) rests by means of a rod (*d*) on a float (*e*) in the shorter leg of a siphon

barometer. Counterpoises are added at *f* to balance the magnet (*b*). A plan of the lever on a smaller scale and a section at A are also shown in the figure. The barometer-tube is made so much larger in the shorter than in the longer leg that a change of one inch in the barometer would move the float in the shorter leg only two tenths of an inch. A rise or fall in the barometer causes a corresponding motion in the horseshoe magnet, and thus varies the intensity of its attraction for the magnets on the pendulum-bob. By proper adjustment this varying attraction is made to furnish the required compensation.

The small error which remains, notwithstanding the above-detailed provisions for correction, is allowed to accumulate, but is determined daily (unless clouds prevent) by transit observations,* so that the exact sidereal time is always known.

The standard sidereal clock registers its beats upon the chronograph record; controls, by electric connection, all the sidereal clocks in the different rooms of the observatory; and drives a sidereal chronometer (*b*, Fig. 5), in agreement with itself, in the computing and time-distributing room.

The secondary regulator of the time of England is the mean solar standard clock at the Royal Observatory, which was specially erected in 1852 for service in the time-signal system, of which it is now the most important instrument. This clock has a seconds-pendulum, which closes an electric circuit as it swings to the right. An electro-magnet in the circuit lifts a small weight, which is discharged upon the pendulum as it swings to the left, and gives it an impulse; this being repeated at each vibration is sufficient to keep it in motion. The pendulum also closes other galvanic circuits—one as it swings to the right, another as it swings to the left—which send currents alternately positive and negative through electro-magnets, alternately attracting and repelling bar-magnets fastened to an axis, which thus receives a reciprocating motion. An arm projecting from this axis moves the seconds-wheel one tooth forward each second; proper gearing gives motion to the minute and hour wheels.

The mean solar standard, besides controlling other clocks, to be enumerated later, drives a seconds-relay (*a*, Fig. 5), which controls a mean-time chronometer (*c*).

All the clocks controlled by the mean solar standard are required to indicate exact Greenwich local time; the error can not therefore be allowed to accumulate, and the means of correction are provided. Carried by an arm projecting from the pendulum-rod of the mean solar standard is a magnet, five inches long, which swings just over a

* The difference between the clock-time of the transit of a star over the meridian (corrected for errors of position of the instrument, and for "personal equation") and the right ascension of the star for the day, taken from the nautical almanac, is the error of the clock.

hollow galvanic coil, called "the accelerating or retarding coil," fastened to the clock-case and operated by a special battery. The attraction or repulsion, between the magnet and the coil, produced by sending currents in opposite directions, gives any required acceleration or

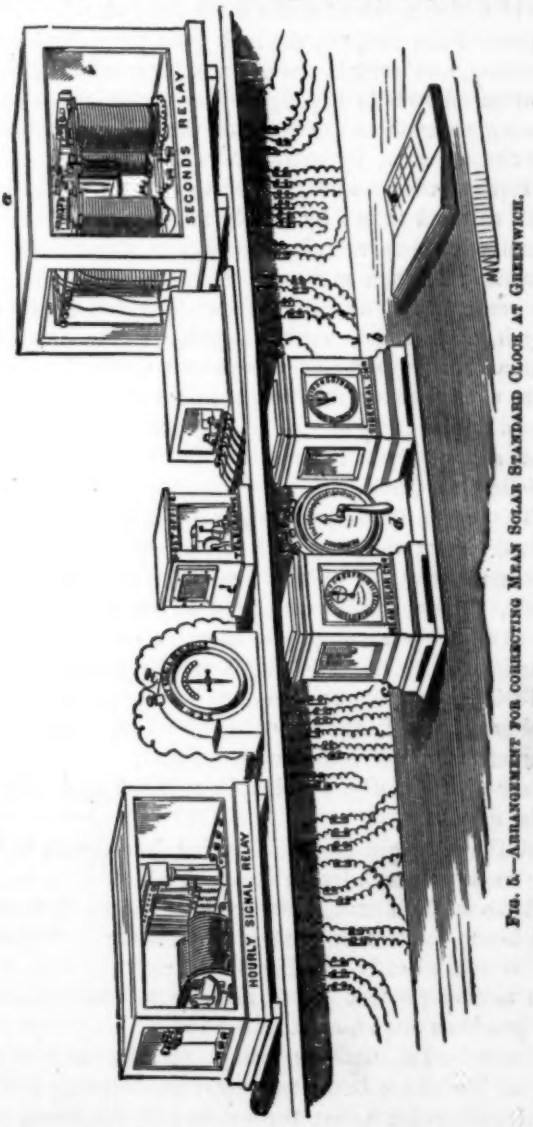

FIG. 5.—ARRANGEMENT FOR CORRECTING MEAN SOLAR STANDARD CLOCK AT GREENWICH.

retardation to the pendulum. Care must, of course, be taken that the correction be not made too quickly, else the clock, instead of being controlled by the current, will break away from control, and the error will be increased. It is now so arranged that the current will produce

a correction of one second in about ten seconds. The correction is made as follows: Between the sidereal chronometer (*b*, Fig. 5) and the mean-time chronometer (*c*) there is a commutator (*d*). By moving its handle toward the right, a current is sent through the "accelerating or retarding coil" which accelerates the mean solar standard; by moving the handle toward the left, the current goes through the coil in the opposite direction, and retards the mean solar standard; in the intermediate position (shown in the figure) no action takes place. The operator, having ascertained the error of the sidereal standard and its sympathetic chronometer, by astronomical observation as described, applies this error to the face-reading of the sidereal chronometer, and gets the exact sidereal time; by simple reduction he finds the corresponding mean solar time, and, by comparison, the error of the mean-time chronometer; he then moves the handle of the commutator, and corrects the error of the mean solar standard, and of all the clocks controlled by it, without leaving his position in the computing-room. This correction can be made at any instant when the exact time is desired; it is usually made at 10 A. M. and 1 P. M., because at those hours a general distribution of time-signals takes place.

The mean solar standard serves for the distribution of accurate time in the following ways:

Nearly all the mean-time clocks in the Royal Observatory are driven by the standard clock; they are, in fact, simply dials whose hands are moved in the same way and by the same battery as the hands of the standard itself. These clocks are placed in the various rooms of the observatory, so that the astronomers have the exact time close to any of their instruments. One of them is in the wall surrounding the grounds, and will be familiar to every one who has visited the observatory; several are placed in the chronometer-room, where the navy and other chronometers are corrected and regulated.

The seconds-relay (*a*, Fig. 5), already referred to, is also driven by the mean solar standard.

Until 1880 the standard clock controlled, by seconds-beats, a number of clocks on a private wire in London, which were made to beat synchronously with the standard by an application of the Jones system,* in which the electric current is used, not as a driver, but as a regulator of clocks already running with small error and by means of their own motive powers. This plan, though still used within the observatory, has been abandoned in London.

With the standard clock is connected another electric circuit, open in two places. These are both automatically closed by the clock, one at the end of each minute, but the other only for some seconds on either side of the end of each hour; so that they are both closed only at the end of each hour, and then only can the current pass.

* For an illustration of the Jones system for regulating clocks at a distance, see article on "Time-keeping in Paris," "Popular Science Monthly," January, 1882.

This hourly current acts on the magnet which drops the Greenwich time-ball daily at one o'clock, and on the magnet of the hourly relay (to the left in Fig. 5) which completes several independent circuits, each controlling a separate line of wire. One of these extends to the central telegraph station at the General Post-Office in London, and another to the London Bridge Station of the Southeastern Railway. The bell and galvanometer marked in Fig. 5 "P. O. Telegraphs" and "S. E. R. Hourly Signal and Deal Ball" show the passage of these currents.

Thus far the service is under the control of the astronomer royal, and he holds himself responsible to send the signals described along each line every hour of the day and night with the greatest attainable accuracy. The signals are generally correct within one tenth of a second of error. Should, however, by any accident, an hourly signal be in error, even to half a second, another signal is immediately sent, announcing that the last was not reliable. Special pains are then taken that the next hourly signal be correct. Here the responsibility of the astronomer royal (except for the dropping of the Deal ball, to be explained later) ends.

On the other hand, it is to be remarked that the Post-Office Department, which undertakes the distribution of these signals to London and the country, agrees to furnish subscribers, not with correct signals, but with the signals which they receive from Greenwich. The Greenwich signals, however, being considered everywhere in England as absolutely correct, constitute a standard from which there is no appeal.

[*To be continued.*]

THE RELATIONS OF THE NATURAL SCIENCES.*

By T. STERRY HUNT, LL. D. (Cantab.), F. R. S.

THE occasion which brings us together is one which should mark a new departure in the intellectual history of Canada. Science and letters find but few votaries in a country like this, where the best energies of its thinkers are necessarily directed to devising means of subduing the wilderness, opening the ways of communication, improving agriculture, building up industries, and establishing upon a proper basis schools in which the youth of the country may be instructed in those arts and professions which are among the first needs of civilized society. The teachers, under such conditions, can do little

* The President's Address before the Mathematical, Physical, and Chemical Section of the Royal Society of Canada, at the first meeting of the society, Ottawa, May 27, 1882. Reprinted, with an added note, from the "Canadian Naturalist," vol. x, No. 5.

more than interpret to their pupils so much of the wisdom of the past, and of contemporary science, as may suffice for the immediate wants of the country, and will have but scanty leisure for original investigation in the field of knowledge. There are, however, never wanting earnest and curious minds who feel an almost irresistible impulse to labor in this field, to enlarge the bounds of thought, and to grapple with the great problems of man and nature. To foster this spirit, to encourage its beginnings, and to extend the influence of its example, should be the aim of wise statesmen and legislators who seek to elevate their kind and ennoble their nation; knowing that the brightest glories and the most enduring honors of a country are those which come from its thinkers and its scholars.

The world's intellectual workers are, from the very nature of their lives of thought and study, separated in some degree from the mass of mankind. They feel, however, not less than others, the need of human sympathy and co-operation, and out of this need have grown academies and learned societies devoted to the cultivation of letters and of science. The records of these bodies in Florence, in Rome, in Paris, in London, and elsewhere, are the records of scientific progress for the last three centuries. Such bodies do not create thinkers and workers, but they give to them a scientific home, a center of influence, and the means of making known to the world the results of their labors.

It was with a wise forethought that more than a century since Franklin and his friends founded at Philadelphia the American Philosophical Society. Its planting then seemed premature, but its vigorous growth during a century has served to show that the seed was not too early sown. This, however, unlike many of the academies of the Old World to which we have adverted, had no formal recognition from the State, and there came a period in the growth of the American Union when the need of an official scientific body was felt. Thus it was that nineteen years ago, in the midst of the great civil war, the American Congress authorized the erection of a National Academy of Sciences, to which, as an American citizen, I have the honor to belong. The aim proposed in founding this Academy was to gather together what was best and highest in the scientific life of the nation, and, moreover, to organize a body of councilors to which the executive authority could always look for advice and direction in scientific matters relating to the interests of the State. In this National Academy—at first consisting of fifty, and now practically limited to one hundred members (a number which it has not yet attained)—the domain of letters is unrepresented; while the Royal Society of London is, in like manner—although scholars and statesmen seek the honors of its fellowship—essentially an Academy of Sciences.

Our infant organization attempts a larger plan, and embraces, with the mathematical and physical sciences, letters, philosophy, and his-

tory, imitating the Royal Irish Academy, which, like this, is divided into two classes; that of the Sciences, on the one hand, and that of Polite Literature and Antiquities on the other. The Institute of France, made up of five Academies, embraces the Fine Arts in its still wider scheme. The second class of our society, with its two sections, aspires to cover the same ground as the Academy of Sciences of the Institute of France, the Science division of the Royal Irish Academy, the Royal Society of London, and the National Academy of Sciences of the United States.

The two sections into which our second class is now divided—namely, III, including Mathematic, Physic, and Chemistry, and IV, embracing Biology and Geology—are, in their aims and their objects, closely related to each other, and widely separated from Sections I and II, which are devoted respectively to French and English Literature and History. Differences in language thus establish in the literary department of this society a natural division into two sections. In the department of the sciences, however, there is no natural basis for a similar division, and it will probably be found in the near future that subjects of common interest will draw more and more closely together our two sections until, as in the various societies which we have named, the distinction between mathematical, physical, and chemical studies on the one hand, and geological and biological studies on the other, will be lost sight of. It seems to me therefore fitting that we should consider the mutual relations of these two divisions, and inquire into the value of the distinctions upon which they have been based.

Apart from pure mathematic, which is based upon our intuitions of space, the sciences which now concern us have to do with material nature, and are properly called natural sciences. It is not their province to look behind or beyond the material world of nature, nor to grapple with the mystery of the Infinite, with which, in the last analysis, the inquirer always finds himself face to face. Our various metaphysical systems are schemes which men have devised to solve this mighty problem, and to translate into intelligible language their efforts to comprehend it. What we call Nature is at once a mantle and a veil in which the spiritual both clothes and conceals itself. "I weave," Goethe makes the world-spirit say, "the living garment of the Deity." This phrase embodies a profound truth. All nature is living; it is, as the word *natura* itself, equally with its Greek equivalent, *physis*, implies, that which is growing, the perpetually-becoming or being born; and this sense, which underlies etymologically the words *natural* and *physical*, should never be lost sight of.

It is a common reproach in the mouths of certain cavilers at science that it does not explain the beginnings of life in matter. That the plant and the animal are living, is evident to them, but they assume that the air, the water, and the earth, the elements from which

the plant grows and is fed, are dead; that life is a mysterious something which comes from without, and is extraneous to the organism. Perhaps we may trace the origin of this conception to the ancient legend, which appears in more than one form, of a human body fashioned out of dead matter and waiting for vivifying breath or fire. The student of inorganic nature, however, soon learns to recognize the fact that all matter is instinct with activities, and finds that a great number of those processes which were formerly regarded as functions of organized bodies are really common to these and to inorganic matter. The phenomena of gravitation, of light, and of electricity, the diffusion and transpiration of gases and liquids, the crystallogenic process, and the peculiar relations of colloids, are all, when rightly understood, manifestations of energies and activities which forbid us to speak of matter as dead. To all of these dynamical (or, as they are generally called, physical) activities of matter, supervene those processes which we name chemical, and which give rise to new and specifically distinct inorganic forms. The attaining of individuality by matter, which has always seemed to me the greatest step in the progress of nature, is first seen in the crystal, but therein the forces of matter are in a statical condition, except so far as certain dynamical relations are concerned. It is not until solid matter rises from the crystalline to the higher condition of the colloid, that it becomes capable of absorption, diffusion, and even of assimilation; that, in a word, it assumes relations to the external world which show that it possesses an individuality higher than the cyrstal, and is, in fact, endowed with many of the activities belonging to those masses of colloidal matter which biologists have agreed to call living.

In these phenomena we have the first developments of individuality and of organization, and I think that the careful student who endeavors with a strong mental grasp to seize the true relations of things will see that we have here to do, not with a new activity from without, but with a new and higher development of a force which is inherent in matter, and thus manifests itself at a certain stage in chemical development. He will then, in the words of a philosophic poet—

> "See through this air, this ocean, and this earth,
> All matter quick, and bursting into birth."

The adjective, *quick*, is here to be understood in its primitive sense of living, as opposed to dead, and aptly defines the notion which I have endeavored to convey. All the energies seen in nature are in this view but manifestations of the essential life or quickness of matter, whether displayed in the domain of what are called dynamical or physical activities, in chemical processes, or in the phenomena of irritability, assimilation, growth, and reproduction, which we may comprehensively designate as biotical.*

* This view, upon which I have insisted in the essay on "The Domain of Physiology," cited below, was well set forth by Rosmini. According to him, in the words of his in-

When we have attained to this conception of hylozoism, of a living material universe, the mystery of Nature is solved. The cosmos is not, as some would have it, a vast machine wound up and set in motion with the certainty that it will run down like a clock, and arrive at a period of stagnation and death. The modern theory of thermodynamic, though perhaps true within its limitations, has not yet grasped the problem of the universe. The force that originated and impelled sustains, and is the Divine Spirit which

> "Lives through all life, extends through all extent,
> Spreads undivided, operates unspent."

The law of birth, growth, and decay, of endless change and perpetual renewal, is everywhere seen working throughout the cosmos, in nebula, in world and in sun, as in rock, in herb, and in man; all of which are but passing phases in the endless circulation of the universe, in that perpetual new birth which we call Nature. This, it will be said, is the poet's view of the external world, but it is at the same time the one which seems to me to be forced upon us as the highest generalization of modern science.

The study of nature in its details presents itself to the mind in a twofold aspect—as historical and as philosophical. The first of these gives rise to a General Physiography or description of nature, which we commonly call Natural History as applied to each of the three great divisions designated as the mineral, vegetable, and animal kingdoms. This physiographic method of study in the latter two gives us systematic and descriptive botany and zoölogy, with their classification and their terminology; while the physiography of the mineral kingdom includes not only systematic and descriptive mineralogy as generally understood, but those branches of geology which we designate as petrography and geognosy, or the study of the constituents of the earth's crust, of their aggregation and their distribution.

terpreter, Davidson, "the ultimate atoms of matter are animate; each atom having united with it, and forming its unity or atomicity, a sensitive principle. When atoms chemically combine, their sensitive principles become one. . . . The unit of natural existence is neither force nor matter, but sentience, and through this all the material and dynamic phenomena of nature may be explained." From the unifications of these sensitive principles, or elementary souls, which take place in the combinations of matter, higher and higher manifestations of sentience appear, constituting the various activities displayed in crystals, in plants, and in animals. From these elementary souls organic souls are built up, and "when these are redissolved into the elementary ones through the dissolution of the organized bodies, the existence of the souls does not cease, but is merely transformed." (See "The Philosophical System of Rosmini," by Thomas Davidson, pp. 284–301.) This volume was unpublished, and these views of Rosmini were unknown to me, at the time of writing the above pages.

The eminent biophysiologist, William B. Carpenter, in an essay on "Life," published in 1847, contends that organization and biotical functions arise from the natural operation of forces inherent in elemental matter.—(Todd's "Cyclopædia of Anatomy and Physiology," vol. iii, p. 151.)

The second aspect of the study of nature, which we have designated as philosophical, regards the logic of nature, or what the older writers spoke of as General Physiology. This is sometimes appropriately termed Natural Philosophy, a designation which is the correlative of Natural History. With this method of study in the organic kingdoms we are familiar under the names of physiological botany and physiological zoölogy, which concern themselves with anatomy, organography, and morphology, and with the processes of growth, nutrition, and decay in organized existences. The natural philosophy of the inorganic world investigates the motions and the energies of the heavenly bodies, and then, coming down to our planet, considers all the phenomena which come under the head of dynamic or physic, as well as those of chemistry. These various activities together "constitute the secular life of our planet. They are the geogenic agencies which in the course of ages have molded the mineral mass of the earth, and from primeval chaos have evolved its present order, formed its various rocks, filled the veins in its crust with metals, ores, gems, and spars, and determined the composition of its waters and its atmosphere. They still regulate alike the terrestrial, the oceanic, and the aërial circulation, and preside over the constant change and decay by which the surface of the earth is incessantly renewed and the conditions necessary to organic life are maintained." * Thus the physiological study of the inorganic world, or in other words its natural philosophy, includes in its scope at once theoretical astronomy and theoretical geology or geogeny.

The twofold division which has been adopted in the scientific class of our new society does not correspond to that which we have just set forth, namely, of Natural History on the one hand and Natural Philosophy on the other; nor yet, as might at first seem to be the case, to the more familiar distinction between inorganic and organic nature. Our Section III has been made to embrace, it is true, much both of the natural history and the natural philosophy of the inorganic world, including, besides physic and chemistry, both descriptive and theoretical astronomy and mineralogy. This same section has also been made to include mathematic, which in itself does not belong to the domain of natural science, though in its applications it becomes an indispensable instrument in the study of nature; whether we investigate the phenomena of physic or of chemistry, or seek to comprehend the laws which regulate alike the order of the celestial spheres, the shapes of crystals, and the forms of vegetation.

Section IV, on the other hand, in its department of biology, includes alike the natural history and the natural philosophy of the vegetable and the animal kingdoms. In this same section has, how-

* "The Domain of Physiology, or Nature in Thought and Language," by T. Sterry Hunt, "London, Edinburgh, and Dublin Philosophical Magazine" (vol. xii, pp. 233–253) for October, 1881; also separately reprinted, pp. 28; S. E. Cassino: Boston, 1882.

ever, been included what we call geology, which is not a separate science, but the application alike of mathematic and of all the natural sciences to the elucidation of both the physiography and the physiology of our planet. So far as geology concerns itself with the history of past life on the earth, or what is called paleontology, it is biological, but in all its other aspects the relations of geology are with Section III. The logical result of this complex character of geology should be either the separation of paleontology from the other branches of geological study, which find their appropriate place in our Section III; or else the union of the two sections through this their common bond.

It will be noticed that in this brief survey of the field of natural knowledge I have not spoken of the technical applications of science, nor alluded to its important aspects in relation to the material wants of life. On this theme, did time permit, I might speak at length. There are two classes of motives which urge men to the pursuit of knowledge; on the one hand, those of worldly fame or profit, and, on the other, the far nobler sentiment which has the finding-out of truth for its object. It would seem as if, by a spiritual law, the great principles which are most fruitful in material results are not revealed to those who interrogate Nature with these lower ends in view. Newton, Darwin, Faraday, Henry, and such as they, were not inspired by a desire for the praise of men, or for pecuniary reward, but pursued their life-long labors with higher motives; the love of truth for its own sake, the reverent desire to comprehend the hidden laws and operations of the universe. To such, and to such alone, does Nature reveal herself. In the material as in the moral order, the promise of achievement is given to those who strive after knowledge and wisdom irrespective of the hope of temporal reward; and the history of science shows that it is such seekers as these who have attained to the discovery of those secrets which have been of the greatest benefit to humanity. The admonition is to all, that we are to seek first for truth and for justice; and with this comes the promise that to those who thus seek all other things shall be superadded.

It is good and praiseworthy to labor to extract the metal from the ore, and the healing essence from the plant, to subdue the powers of electricity and of steam to the service of man. To those who attain these ends the world gives its substantial rewards; but far higher honors are instinctively rendered to those who by their disinterested researches, undertaken without hope of recompense, have revealed to us the great laws which serve to guide the searchers in these fields of technical science; to those who have labored serenely, with the consciousness that whatever of truth is made known by their studies will be a lasting gain to humanity. "Thus," to repeat words used on another occasion,* "it ever happens, in accordance with the Divine

* "The Relations of Chemistry to Pharmacy and Therapeutics," an Address before the Massachusetts College of Pharmacy, by T. Sterry Hunt. Boston, 1875.

order, that the worker must lose himself and his lower aims in his work, and in so doing find his highest reward; for the profit of his labor shall be, in the language of one of old, to the glory of the Creator and to the relief of man's estate."

BRAIN-WEIGHT AND BRAIN-POWER.*

By J. P. H. BOILEAU, B. A., M. D.

ALTHOUGH the connection between the relative weight of man's brain and his intellectual development is very well known, and several illustrations of this connection have been published, I feel assured that the following notes of a remarkable case may not only well be added to the list of those already recorded, but that it is desirable that this should be done. It is the case of an officer who died at Netley last year, and I am indebted to a published memoir for some particulars of his life.

A Scotchman by birth and parentage, he received his early education in Edinburgh, and afterward went to Wimbledon School previous to entering Addiscombe, where his career was exceptionally brilliant. At the final examination there, he scored an unusual total of marks, gained the sword of honor and Pollock medal, and several prizes for specific subjects. On leaving Addiscombe in 1858 he proceeded to India, where he was employed altogether in civil duties. At the time of his death he was superintendent of the telegraph department. With no military distinctions, he was, nevertheless, one of the foremost men in his corps. Highly gifted intellectually, duty no less than inclination prompted him to cultivate his mind as a preparation for advancement, for he held strongly that no one is fit for highly responsible positions who fails to keep himself as far as possible on a level with current events, and with the thoughts, investigations, and discoveries of the day. His wide reading and tenacious memory made him a man of mark in any society. His opinions were his own, formed independently, expressed, if necessary, forcibly, and followed always courageously. He was an exceptional man, and his large-hearted and wide-reaching sympathy won him admiration and love among high and low. His remarkable qualities were as conspicuous in his earlier as in his later years. He was a standard of conduct to his schoolfellows, and, when at Addiscombe, the governor did him the extraordinary honor of making a private report to the Board of Directors of the East India Company, which was quoted by the chairman on the examination day. The reputation with which he started increased daily, and was sustained to the last. But the strain was too great. Exposure to a pernicious climate—and his physical strength led him to expose himself only too

carelessly—for twenty-four years, with but eighteen months' leave, weakened a naturally magnificent constitution, and he was compelled to take furlough. His intellectual vigor, however, was shown nearly to the last, and only a few days before death he expressed his capability of undertaking difficult mental work. But a sudden change set in, and in a few days proved fatal.

During his stay at Netley he suffered from extreme debility, induced probably by intractable diarrhœa. A day or two before death he complained of severe headache, and his axillary temperature rose from 101°–102° to 106° Fahr.

It is very much to be regretted that, at the time I was called upon to make the autopsy, I was not in possession of the facts narrated, for, had I been, the examination would have been more complete in many points. The diagnosis of the case was very obscure; but hepatic abscess was suspected, and it was to clear up this point that the examination was made. The severe headache, however, and the rise of temperature, pointed to some cerebral or meningeal mischief, and it was thought advisable to find out if such existed. For this purpose the cranium was opened.

Abstract of Autopsy (made not only with the full permission of relatives, but, I believe, by request).—Cranial bones very dense; dura mater extremely vascular; brain-substance generally firm and normal. On opening the left ventricle pus was observed in the anterior cornu; the origin of this was in the anterior part of the intraventricular portion of the left corpus striatum, which here was quite destroyed and broken down into soft shreds. Before dissection the brain weighed 26,130 grains avoirdupois, or 59·72 ounces. After examination, a portion of it, weighing 22,785 grains, was found to displace eighty-six cubic inches of water; the specific gravity was, therefore, 1·049. The lungs were perfectly healthy, with the exception of the lower lobe of the right. In this there was a circumscribed abscess-cavity, measuring in its longest diameter three inches. It communicated with a small abscess in the liver, through an opening, about the size of a florin, in the diaphragm. The heart was quite normal. The lining membrane of the great blood-vessels was deeply blood-stained, that of the aorta being very much roughened, in patches, by atheromatous degeneration. Jejunum, ileum, and colon normal; no trace of ulceration, but the solitary glands of the latter were large and prominent. The liver presented a uniformly brown color throughout, and was much softened. In the upper portion of the right lobe there was a small abscess, about one inch in diameter, and nearly surrounded by a dense, thick, fibrous envelope. This abscess communicated with the lung. The spleen was slightly enlarged, weighing 4,375 grains. The kidneys appeared to be quite normal; they were enveloped in a large amount of fat.

The chief interest in this case lies in the great weight of the brain, and its high specific gravity, in relation to the highly gifted intellectual

power exhibited by the individual during life. As this brain weighed very nearly 60 ounces, it exceeds that of all others usually quoted, with the exception only of Cuvier's, which weighed 64½ ounces, and that of Dr. Abercrombie, which weighed 63 ounces.* Sir J. Y. Simpson's brain weighed 54 ounces, and that of Agassiz 53·4 ounces. It is well known that the average weight of the adult male brain is under 50 ounces. The specific gravity of the brain I examined was 1·049, and this is as high as any recorded. From Professor Aitken's work I find that the average specific gravity of the brain is 1·036, and the highest specific gravity of the densest part of a brain ever taken by Professor Aitken, or any one else, I believe, is 1·049.

The weight of the brain in this case was, in the first instance, taken by the orderly corporal in charge of our microscope room, and recorded by him on the blackboard in the mortuary. I immediately verified its accuracy by weighing the organ myself, and I also verified the correctness of the weighing-machine. The specific gravity was taken very carefully. Surgeon-Major Hogg, Army Medical Department, was present at the time.

The average cranial capacity of the adult male head is, I believe, about 90 cubic inches. Cuvier's is reported to have been about 118, In the case which I now record it must have been about 108.—*Lancet.*

THE CELL-STATE.

By Professor FERDINAND COHN, of Breslau.

NOTHING is more sure than that all life is subject to age and death, and yet nothing is more contradictory to our feelings. In the vigor of youth our body feels as if it was created to last for ever; why must the highest work of art wear out and break down with time? The more formidable the contradiction between inexhaustible life-joy and inevitable fate, the greater the longing which reveals itself in the kingdom of poetry and in the self-created world of dreams hopes to banish the dark power of reality. The gods enjoy eternal youth, and the search for the means of securing it was one of the occupations of the heroes of mythology and the sages, as it was of real adventurers in the middle ages and more recent times. . . . But the fountain of youth has not been found, and can not be found if it is sought in any particular spot on the earth. Yet it is no fable, no dream-picture; it requires no adept to find it: it streams forth inexhaustible in all living nature.

* A case is recorded in the "British Medical Journal," October 26, 1872, by Dr. Morris, in which a brain examined at University College, London, weighed 67 ounces. It was that of a bricklayer, who could neither read nor write.

Nature continues eternally young; the earth adorns itself every spring with leaf and flower, having the same freshness and youthful vigor as when for the first time He "let it bring forth grass, the herb yielding seed, and the fruit-tree yielding fruit after his kind." The grasses and flowers, it is true, which this year are cut or withered, the leaves and blossoms which the wind has to-day blown from the trees, will not assist in forming its robe in the next spring, but Nature draws out new shoots from the old roots, new leaves from the old branches, and thus rejuvenates herself with every new year. And although the human race, although also the other kinds of animals and plants, show as yet no trace of age in spite of the numerous thousands of years in which they have dwelt on the earth, still each individual is perishable, it grows old and dies; but new generations shove themselves uninterruptedly into the gap, so that the whole abide in the freshness of youthful vigor. Rejuvenation so dwells in nature that every individual runs through a limited circle of development, and is finally worn out and cut off, to be replaced by fresh members which pass anew through the accomplished cycle.

I.

If we apply this view which we have gained of the rejuvenation of nature to the consideration of a single being, whether it be man, animal, or plant, we shall perceive that all life rests upon a constant renewal. Life is an uninterrupted contest with death, which attacks it every moment, but is beaten back by rejuvenation. It would be an error to represent a living being as anything constant, its appearance as anything steady; life in truth resembles a water-fall, which only apparently preserves a constant form, while in reality none of the particles of water keep their places, but are continually removed and replaced by new ones. The visible form of stillness is kept up only in perpetual movement. Life resembles a flame, which restlessly consumes itself and can shed an even light only when new particles come up in place of those which have been burned, only to be dissipated in their turn a moment later. So in living bodies the combination and arrangement of the matter on which their outer form and internal disposition depend are at no two instants the same, but an uninterrupted change of matter is taking place. The particles which are together in this moment at one point are in the following moment separated and replaced by others. For only a short time are the atoms of which bodies are built up adapted to the service of life; sooner or later they leave it in order to follow the free play of the forces of attraction which join the elements in the enduring combinations of lifeless nature. Therefore, the living body is obliged constantly to take up from without new elements of nourishment, by means of which it repairs its loss; and these insinuate themselves so closely in the place of the separated ones, that even the eye of the naturalist,

armed with the most effective aids supplied by modern science, has only recently remarked, after a long time, that any change has taken place.

In reality every living body is subject to an uninterrupted change, which goes on in an appointed course. Life is like a stream, which gushes out of a hidden spring; slowly increases, flows on for a time with even strength, finally with diminishing velocity, to disappear in the sea of eternity. We designate the course of changes which every living being, plant, and animal, as well as man, goes through, as its development. Development begins with the moment of birth and ends with death.

But with the death of the single being its race does not disappear; the property dwells in every living being by which a part of it can drop off from the whole, continue to develop itself independently, be nourished and rejuvenated by a change of matter. We call this dropping off of a part, capable of development, from the whole, propagation; with propagation is transferred the history of development; the separated part, which we denote as an egg or spore, a seed or embryo, a bud or spawn-knob, passes in substance through the same course of changes as the whole from which it has been separated. Like arises from like; the children resemble their parents, and, as these again resemble their ancestors, the character of the species is kept up essentially unchanged, in spite of the perishability of individuals, through all the generations.

That life is nothing but a constant development and an uninterrupted rejuvenation is expressed in the plainest and clearest manner in the world of plants. It is, indeed, not easy to comprehend the life of plants aright, and many regard the term as a figure of speech, not properly applied. Plants, they say, do not feel or move; they have no consciousness, no soul, like animals; how can we speak of their life? If motion, feeling, and consciousness alone constituted life, there might be some doubt as to whether plants lived, though it would still be worth while to inquire whether these higher attributes were really wanting in plants. Darwin has lately shown, in connection with many older observations, that all the parts of plants participate in a regular circling motion, and that single organs show sensibility enough to make them comparable with the brains of the lower animals. But when, instead of the highest acts of life, we confine ourselves to its general and essential manifestations, it becomes undoubtedly clear that plants are living in the same sense as animals and men. Only plants are distinguished, not from animals generally, but from the higher animals that rank nearest to men, and from which our conceptions of animal life in general have been formed, in that in them unity, or individuality, is expressed in a much more imperfect manner. The mammal, bird, fish, insect, is a separate, single, and indivisible being. Its members are fixed and limited in number; not one of them can

perform its functions when separated from the whole. No part, not the smallest, can be separated from the body without the whole suffering.

It is very different with the plant. A tree indeed appears to be a single being, sinking the net-work of its roots into the ground, raising its slender trunk into the air and spreading out above the web of its limbs and boughs. The members of which the tree consists may be regarded as its organs. It sucks up its nourishment through its roots, it breathes through its leaves, it propagates its species through its flowers. But the connection of these members with each other is of an infinitely looser character than that of the organs of the animal. I can strip as many leaves as I please from a willow, the rest lives on; I can cut off its limbs, those that are left grow more vigorously; I can cut it down near the roots, new shoots spring up from the stump; I set the rootless stem in moist earth, and it continues to live. If I wish to make a layer, I have only to plant the end of a bough, and it takes root and grows. In many plants a single leaf has the capacity of living and growing. The plant is not therefore indivisible, like the animal; its individual members are in a much higher measure independent and competent to live. We may say the animal is a single being, each of its members is only a part, not itself a whole, only an organ, not itself an individual. The plant, on the other hand, is a composite being, a chain of individuals, each of which possesses an independent life, but all of which are connected in a collective life of a higher order; the plant is an organism the organs of which are themselves organisms.

This relation may be made clear by a suitable figure. A state is, without doubt, in many respects a single organism, which maintains an independent, often sharply defined, unchanged character through centuries, and marks its domain as an indivisible, also as a real individual. Each state has its own development-history: it is founded, it grows, reaches its prime, and decays; it has its life-economy, for the functions of which it maintains its particular organs, its officers. The state also acts in external affairs as a single organism; it makes war, it establishes enterprises for the general benefit, it builds important works, etc. But if the state thus appears as a single whole, so also it may be regarded on the other side as a collection of provinces; each province is a state in miniature, likewise organized in itself; and history furnishes us with numerous examples in which single provinces have been able to cut loose from the collective state and maintain themselves as independent state-organisms. The province, again, can be regarded as an association of villages which represent the smallest social organizations; every village is also a state in miniature, with independent economy, and capable of maintaining itself independently in case of necessity, and, in fact, of growing up, as Rome, Carthage, and Venice have shown, into mighty states. If we carry our similitude to the end, we may liken the animal to a compact, centralized,

unitary state, the members of which have entirely lost their independence, and in which a single will rules the whole; while we may represent the plant as a freely organized federal state, the members of which, in spite of their resignation to the whole body, have yet preserved a certain degree of independence and self-administration.

In the federal state of the plant the limbs and boughs correspond to the provinces, the leaves to the villages; but the village is not the last member of the chain: it is itself a union of citizens, each one of whom, though a member of the state and the village, is an independent being who lives first for himself, and has his own household, all of whose efforts are first directed to the maintenance of his own existence. But while with a just egoism the citizen knows his own good as his immediate object, he thereby participates directly in the advancement of the state organism and contributes to the support of the whole state. Every citizen goes through his independent development from birth to death; but the village does not die with the death of the individual, for in his stead come his children to fill the vacant place; and the village and state are renewed in the unbroken succession of generations.

It is the same in the plant-state. If we compare the leaf with the village, it also consists of a larger or smaller number of individuals which may be regarded as independent organisms. The citizens, through the union of whom the plant-state is formed, are called by the botanist plant-cells. All plants, without exception, are composed in all their parts of cells, just as every building, from the palace to the hut, consists of building-stones or timbers. Every plant-cell pursues an individual life. Its first effort is only to maintain and develop itself; it takes its own nourishment and assimilates it, and finally dies, after having, as a rule, first left a posterity in its place. As the cells unite to form cell-villages in the leaves, these unite again to form the provinces of the foliage-boughs, and enter into an interchange of life with each other, and so they maintain the life of the whole plant in the same manner as the collective state-life comes into being through the interworking of the lives of the individual citizens. What we see going on in the life of the plant in the germ and shoot, in flower and fruit-bearing, are only head and state actions in the development of the cell-state and its citizens.

Our eyes can not perceive these citizens of the cell-state. It is not strange, then, that their existence escaped the knowledge of naturalists till about two hundred years ago. They would still be concealed, and the key to the comprehension of plant-life would be withheld from us, had it not been for the microscope.

We owe it to the microscope that, where the naked eye perceives only uniform masses, we can now distinguish a wonderful diversity of beautiful tissues; and that where a rigid stillness seemed to prevail, a fullness of life-processes quite incomprehensible to us is concealed.

The microscope shows us in the plant, which was able to give to the naked eye only obscure signs of its inner life, a highly organized state-life of restless development and renewal.

We have represented the citizen of this state, the plant-cell, as an exceedingly simply formed being: it consists of a round body of soft, slimy substance, like a sack, the interior of which is filled with a watery juice. The soft substance, forming the wall of the body, is called protoplasm; it is the most important matter in all nature, for it alone is the bearer of life. With slight changes it forms not only the bodies of all plant-cells, but also the white and yolk of the egg, flesh and blood, the substance of the brain and nerves, milk and cheese, the skin and hair of animals. While in lifeless nature nearly every kind of stone has a different chemical constitution, in the world of life one and the same fundamental substance forms the basis of the bodies of plants, animals, and men.

But if the plant-cell consisted simply of soft protoplasm, it would not be able to resist the presence and assault of strange bodies; therefore it is surrounded with a hard shell, which it prepares as a dwelling and for its protection, in a similar manner as the snail forms its shell, by secreting over its surface a matter which soon hardens into a firm, transparent envelope. This shell, which is called the cell-wall, does not show the most minute opening, but incloses the protoplasm perfectly tight. We might, therefore, liken the cell to an egg in which the soft, living contents are concealed in the hard shell.

Plant-cells vary greatly in size. Those of elder-pith and of the begonia-leaf may be perceived, with the naked eye, as resembling an extremely delicate lattice-work; the pollen of rye and of melons separates in water into little dust-particles—single cells, just at the limit of visibility. A drop of malt-yeast, on the other hand, is resolved under the microscope into millions of oval fungus-cells, one or two thousand of which would hardly fill the space of a centimetre. Plant-cells average about the size of a hair's-breadth, many only about a third or a fourth as much; others are larger, and particularly longer; the single fibers from which cotton and linen threads are spun are plant-cells which, although very slender, are from two to six centimetres long.

But in nature nothing is great and nothing little, and there is room, even in the smallest cell, for the greatest diversity and development of the powers of life. A continuous formation and transformation, origin and decay, a constant change of matter, is going on in every cell; reception and assimilation of food, inspiration and expiration; certain atoms which have become of no use for purposes of life are cast aside, others are taken up from without in their places; on this food and change of substance depend the renovation of the cell and the maintenance of its life. Evidently not solid substances are appropriated, for we know that the cell is incased in a perfectly closed

envelope; but liquid and gaseous foods can be easily absorbed. Although the most perfect microscopes have never made any holes visible in the cell-envelope, there is not the slightest doubt that this envelope is porous, like a fungus, but that the pores are infinitely finer. Therefore, we may understand that, when a cell is placed in a fluid, the envelop absorbs it to fullness, and conveys to the inner protoplasmic body as much as it requires; and, inversely, certain parts of the cell-juices, which the living protoplasmic body does not need for itself, are transpired through the pores of the envelope and become applicable to the use of other cells; and the same may take place with air and gases.

The old naturalists believed that all bodies were composed of four elements—fire, water, air, and earth. Modern physics and chemistry have divested these elements of their high importance; but they are still full of meaning to the life of plants. Earth, air, and water are the food of plants; fire, or rather light and heat, are the forces that set agoing the play of life in the cells. The most important food of plants is contained in the mineral solutions which the water, penetrating the soil, extracts from it, and in the oxygen and carbonic acid which they derive from the air.

Water, earth salts, and the gases—the raw materials which the plants suck up—are changed within the cells into starch and sugar, gum and woody fiber, albumen and wax, oil and resin, into powerful medicines and deadly poisons. The simplest plant possesses an art which the most skillful chemist has not been able to learn from it. It is true that the chemist can artificially prepare in his laboratory many of the substances which the plant-cell likewise produces; he can convert the starch of the potato into the sugar that gives the wine-grape its sweetness; this, again, he can transform into the fruit-acids which, in connection with the sugar, give the berries their fresh and agreeable taste; he can even produce the flavor of the fruits from the fusel-oil which he obtains by the fermentation of the sugar. He can make the oil of bitter almonds from benzoic and formic acids; he can, with as good art, imitate the pungent taste of the pepper, and the biting one of the mustard-seed, and the narcotic poison which only the night-shade has hitherto prepared for the healing of sore eyes. He can produce from the sap of firs the crystal-needles of the vanilla, for which a Mexican orchid has heretofore been obliged to give up its pods; from the distillation of wood he obtains a smoky fluid, from which he procures salicylic acid, for the production of which the flowers of the meadow-sweet or the bark-tissues of the willow were formerly required; and from this he makes also the ink-coloring gallic acid, which formerly only a little wasp knew how to draw out by its sting from the cells of the oak, and the aroma of the wood-ruff. He has made the work of the cells in the madder-root superfluous, for he has fabricated its costly dyes, along with a hundred other splendid pigments, out of tar-oil and stone-coal; and is now on the point of taking

its work away from the indigo-plant by artificially producing indigo. But a raw material which has at some time been brought forth out of the laboratory of a living plant-cell always lies at the foundation of all these manipulations of the chemist, wonderful as they are. And, notwithstanding the immense progress that modern chemistry has made within the last ten years, its art is still limited at this point: no prospect yet exists that it will be able, artificially, to produce the most important of all the substances that go to build up the bodies of animals and plants, and to form their living cell-tissues—protoplasm, or the envelope of the plant-cells, the matter of the muscles and nerves. Chemistry shares this limitation of its means with animals. No animal can live on air, water, and earth alone, like the plants; no animal can combine the simple chemical combinations, as they occur in lifeless nature, into the life-substance protoplasm. The animal must draw the substance of his flesh and blood from the plant, for his own vital forces are not competent to produce it. The plant-cells alone possess the faculty of ennobling the simple combinations of lifeless nature into matter fitted for life. Every cell, furthermore, possesses another art, that of forming different fabrics out of the same raw material. Hence arises that infinite diversity of substances of different properties which are drawn from the vegetable kingdom. Close together, in the shadow of the same wood, grow crow-foot and wood-ruff, centaury and night-shade; the same soil gives food to their roots, the same air plays around their foliage; and yet the cells of one secrete a pungent, those of another a narcotic poison, those of a third a bitter medicinal juice, those of a fourth an aromatic flavor. The cell utilizes a part of its food for its own growth; but, sooner or later, the growth ceases, and the cell, keeping the form and size it has acquired, becomes a permanent cell. It is round or oval, or resembles a many-sided crystal. Some cells become flat and square, like a tile; some put out rays, like a star, or form a zigzag, like the wall of a fortress; many lengthen themselves out. The inner structure, also, of the cell changes with age; the envelope, delicate and thin in youth, afterward receives accretions and ornaments. Some cells have within a hollow screw-way, like a winding stair; in others, the inside is covered with beautiful nettings, rings, flutings, or lattices. Most cells thicken their casings, as the oyster does, by adding new layers over the older ones; and, when their hollows are quite filled up, they may rival stones and bones in hardness, as, for example, the cells of the iron-wood and the ivory-nut.

As the cell-wall grows thicker, fluids and gases penetrate its invisible pores with more difficulty; and with continuous increase of thickness the living protoplasmic bodies inhabiting its interior must finally die for want of food. They in effect build their own coffin, immure themselves living in their own cell-prison. But a wonderful provision prevents the food being entirely cut off. While the cell-wall is arch-

ing itself up more closely and thickly, a few doors and windows are still left open in it, through which communication may still take place with the adjoining cells; this occurs by the cell-wall not becoming strengthened at particular points; and when, in the course of time, the shell has become still thicker, these places appear as pores or canals, which lead outwardly from the interior of the cell. And it is worthy of remark that at each point where such a canal penetrates the thickened cell-wall a corresponding passage is also left open in the next cell, so that the two canals meet each other, and are only separated by a thin partition. Communication continues uninterrupted by these pore-canals.

The plant-cell is, nevertheless, subject to the fate of all life—it grows old and dies at last. It seldom survives a summer; toward the end of the fall its activity becomes weaker. Dissolution gradually overcomes the dead protoplasmic bodies, and only the empty cell-wall is left, which may continue to exist as a vacant chamber for years and centuries after the living nucleus has perished. As a rule, the cell propagates itself before it dies; as an earth-worm may be divided into two parts, each of which will become an independent individual, so the parent-cell divides itself into two daughter-cells, which supply the place of the mother, and continue their life-activity with renewed vigor.

II.

Such in its principal features is the economy of the plant-cell. It is fed by the absorption of fluid and gaseous foods; it elaborates those foods into the most diversified products; it respires; it strengthens and thickens its shell, yet in such a manner that it can continue in living intercourse with its neighbors; it propagates itself by splitting into daughter-cells; it grows old and dies. Let us now glance at the arrangements and laws according to which the cells act in organic connection as citizens of a single state. As there are wild bees that do not live together in a hive, as there are human tribes that wander around in the woods without organic connection, so there are plant-cells that remain isolated during all their lives; they all perform in the same manner the business of their whole existence, which is highly primitive, and unadapted to perfection; their progeny does not continue in social connection, but separates into wholly free individuals. Such plants, which always consist of single cells, are called one-celled; they are found among the lowest forms of the microscopic world, among the algæ and the fungoids. The green coating that covers the rocks, the tree-trunks, and the shingles of the roof, is resolved by the microscope into innumerable green round cells; the brown scum that floats upon ponds and ditches exposed to the sun, the yeast-plant, the bacteria that produce putrefaction, are one-celled plants of this kind.

Generally, however, the plant-cell is, like man, a social being, which finds its true calling only in state-life. In most growths, from that of

the moss to that of the oak-tree, an incredible number of cells come together to form an ordered state; the number of cells in a small plant may be compared with the number of the inhabitants in the most powerful kingdoms; and I have estimated that at least ten million cells live together in a potato five centimetres (about two inches) in diameter, and that a pine-stem twenty-five metres (about eighty feet) high and twenty-five centimetres (about one foot) in diameter, of symmetrical growth, contains more than a hundred milliard wood-cells.

The leading idea that knits the plant-cells into a state-organism is the same as in the bee-hive or the human state, the division of labor. Each cell possesses its individual life and passes through its particular course of development; it, however, does not undertake all the works of life, but limits the circle of its activities so as to reach a greater perfection within a smaller limit. In this it works not for itself alone but for the other cells also, while it commits to them those requirements for the satisfaction of which its individual activity is not sufficient. Thus the different functions are so divided among the different cells that one makes this, another that, occupation its own special business. The cells of the cell-state so arrange themselves in their different offices that they work mutually into each other's hands: one lives for all, all for one. The more perfectly the division is carried out, the more completely can each cell fulfill the duty for which it is designed; the more highly organized is the cell-state, and the higher position does the whole plant take in the order of growths.

As in the bee-hive there are working-bees, so in the cell-state of the plant there are working-cells; other cells are fitted for sexual existence, like the drones and the queen in the bee-hive, so as to insure the production of posterity and the foundation of a new stock.

The cells which discharge the several functions in the plant are not scattered confusedly in the mass, but are always grouped in greater or smaller numbers of individuals precisely adapted for this or that function, and together form a tissue. Plant-anatomists distinguish three kinds of tissues, each of which discharges a particular function: The fundamental tissue is composed of the cells which are the real workers in the state; the circulating tissue, of those cells on which the duty of transportation is laid; the bark-tissues, of those to which is assigned the protection of the cell-state against the outer world. We might designate as a fourth class the reproductive tissues, as including the cells adapted to propagation, which are producing by continuous divisions new colonies, new leaves and flowers, new buds and seeds.

The cell-state is, to speak with Herbert Spencer, organized after the type of an industrial state, in which numerous industrious workmen are co-operating on a footing of democratic equality to ennoble the raw material of lifeless nature and convert it into the precious and diversified productions of life. The fundamental tissue in a measure represents the working-class; trade is represented in the cells of the

vascular tissue, which are engaged, by means of well-trodden routes of communication, in supplying the most remote parts of the domain quickly and abundantly with food and raw material and in exporting the finished fabric. But a defenseless kingdom would be an easy prey to its enemies; therefore the cell-state maintains, but peaceably, and with no view to aggression, in the cells of its bark-tissues, a standing army, on which depends the defense of the whole realm at its borders. As Sparta believed it was most securely defended by the living walls of its citizens, so does the cell-state. The cells of the bark-tissue form a close cordon, through which no rain-drops, no hurtful gas-puff, no hostile animal, no disease-generating spore can penetrate. They wear a hard, siliceous armor, or are protected by an impermeable coating of wax. They have no other purpose, they do no other work, than in compact array to ward off hostile attacks. Single cells advance before the line and oppose attacks with sharp-cutting weapons, finely pointed briers or thorns, or weave themselves into intricate abatis, in which hostile insects become entangled by their feet. The points of many of these thorns are poisonous, as in the nettle, which, when touched by the hand, breaks off and remains in the skin, and fills the invisible wound with one of the strongest poisons known to nature and science.

The cells of the bark-tissues are locked so closely to each other that, like the members of a brave phalanx, they would be torn apart before they would separate from each other; and they can be separated from the other tissues only as a connected layer, a thin membrane that may be drawn off from all plants, and is known as the epidermis. This living cell-fortification is interrupted in many places by round openings like gates, which may be closed by a couple of cells as if with double doors, by the opening of which the access and egress of gases and vapors to and from the interior are permitted.

Thus the plant is protected from external enemies; but its most dangerous adversaries are the hungry members of its own kingdom. Not all plants are supported by peaceful labors; there is among them also a predatory horde, whose members, the parasitical plants, unfit for honorable occupation, and bearing the marks of their baseness in their pale color and offensive smell, lurk in the darkness and in concealment till they can find some victim to attack and overcome. Now is the strength of the living wall of the plant tested: as long as it is unbroken, the assault is repelled; but the persistent enemy presses into the smallest opening. Woe to the tree from which the wind has broken a limb, or in which the careless gardener has made a bad cut! The microbes, whose spores are floating through the air in unwholesome clouds, and fall with the dust, settle upon the wounded surface, and soon its whole cell-structure is pervaded by their destructive webs.

In peaceful times the other citizens of the cell-state attend to their

business undisturbed, under the protection of the bark-cells. The cells of the fundamental tissue, which is inhabited by the working-people proper, unite in close association; between them courses, with numerous branches, a system of canals, which are connected with each other like net-work, and find their exit through the clefts. In this manner the air which they require for food and respiration is introduced to the cells, and by the same road escape the gases and vapors which the cells throw off, and which need to be removed.

The fluid foods are carried to the working-cells through the vascular tissue in a special system of ducts, conduits, and fibers, which, joined in strings and bundles, penetrate all the organs, the roots, stock, limbs, and leaves, and are known as the ducts, or vascular bundles; they may be most easily perceived in the leaves when held against the light, where they form the most beautiful vein-work. These conducting vessels are also traffic-roads, in which the products of the working-cells of the main tissue are transported to other places, where they are put to use. Thus an unceasing activity, like that of the bee-hive, prevails in the cell-state of the plant. Gases go in and out; juices circulate up and down, absorption and evaporation, distillation and refining, forming anew, remodeling, or destroying the old, are going on all the time without rest or cessation for an instant. As long as the cells live, they are active; when they cease to work, their death is near. No one thinks, when he looks at a plant, what restless activity is at work within it, for the cells perform their artful labor in stillness, without buzzing and flying around as the bees do.

The wealth of those lands that possess coal-mines and ore-beds is highly prized. But these treasures are not confined to single provinces. Immense mines of ore, inexhaustible coal-beds, surround us wherever we may be. For the minerals that are contained in the field-soils are quite as precious as are the mines of iron and zinc, yes, even of gold and silver. Man can not live on gold and silver; but out of the minerals of the field-soil, out of potash, lime, phosphoric acid, ammonia, and sulphuric acid, the cell-state of the plant prepares bread on which we live, linen in which we clothe ourselves, wood out of which we make our vessels and tools, and the remedies which when we are sick restore our lost health to us. The cells of the roots, like hewers and miners, sink numerous shafts in the spaces assigned to them, drive their galleries toward all points of the compass, in order to break up these mineral treasures, separate them from the incasing stone, and set the machinery of service in motion; day and night with inexhaustible diligence, they extract atom by atom of potash and ammonia, phosphoric and nitric acid, and, without working up their ore, deliver it over to the conducting vessels which transmit it by their powerful system of sucking and forcing pumps to the stem and the leaves. The leaves are cell-villages which perform their daily tasks in the air and the light. Their principal business is to obtain coal, which is the chief

constituent of the vegetable body. Our atmosphere is an enormous coal-mine, many miles in thickness, that can not be exhausted in thousands of thousands of years. The coal, indeed, is not found pure in the air, any more than the metal in the ore, but is in combination with oxygen as a transparent gas, carbonic acid, and a peculiar art is required to separate it.

In the mining districts, smelting-houses are erected beside the pits, where the noble metal is extracted from the impure ores. The green cells of the leaves combine the art of the miner with that of the smelter, and have the power of extracting the pure carbon from the atmosphere. In order to perform this work, they must be shone upon by the sun, for the sunlight alone can excite in them the marvelous faculty. Having extracted the carbon, they combine it with water and with the mineral substances that have been drawn from the soil, and prepare from them the living matters out of which the plant itself builds up its cells, and which, taken up into the body of an animal, is transformed by it into flesh and blood.

As bees do not at once consume all the honey they collect, but lay away a large portion of it in special cells for winter provision, so a portion of the cells in the plant are set apart for the storage of capital in anticipation of the necessities of the future. On the approach of winter the leaves discharge the greater part of what they have produced through the conducting vessels, which convey it to a subterranean magazine. The cells of the root-stock, the tubers, and the bulbs, protected from the frost by their covering of earth, are filled with starch, albumen, and other valuable food-material, which will be used again in the coming spring when they will be most needed, for the expansion of the leaves and flower-buds. When we eat a potato, we appropriate to our own nourishment the provision which the careful mother-plant has laid up in its cells during the previous year for the growth of the next spring; and we do what is substantially the same as when in the fall we rob bees of a part of the honey which they have gathered for the supply of their own state.

A necessary consequence of the short duration of the life of the single cell is that a part of the plant, the cell-village, in which the life-processes are now active, is generally dead in the next year, and unfit for all work. Therefore the cell-state is subject to a constant mortality. The leaves which perform their work in the summer wither and drop off in the fall; the cells of the root, also, which then drew up the fluids from the soil, and those of the stem, which conducted it upward, have at the same time grown old—have become woody, as the botanist expresses it.

The greater part of the plant does not, in fact, survive the first year. Most herbs sprout in the spring, blossom in the summer, ripen their seed in the fall, and perish in the winter. Trees, on the other hand, bushes and shrubs, possess a regular economical administration.

They lay up, till fall, provision in their stems or roots, which does not come into use again until the next spring. And, when the collected capital enters into circulation again after the first warm days, the old cells are not able to undertake anew the business of turning it to use. The plant does not put its new wine into old bottles. It forms new cells, new organs, adapted to the demand of the new season. Now those tissues which we may call the procreative tissues come into play. Their cells begin to undergo a continuous division; their number is multiplied—new colonies, new cell-villages are founded. New points are formed at the ends of the roots, the young cells of which suck food from the soil with refreshed vigor; a new conducting tissue is formed in the stem between the wood and the bark, representing a new yearly ring. A grand act of renovation has also been in preparation at the ends of the limbs and twigs and at the bases of the leaves. Little cones of reproductive tissue are developed at these spots, in which innumerable cells originate by division, and, in accordance with an innate structural plan, a definite number of vesicles shoot in most symmetrical order of arrangement from each of these cones. Every cone is the beginning of a little stalk, the vesicles that grow from them are the beginnings of leaves; the whole structure is covered with thick scales and is now called a bud, in which the tender beginnings of leaves are protected by the scales from frost and storm. The buds are started in the summer, completed in the fall; are dormant during the winter, and are awakened to new life in the spring. The scale-armor now becomes superfluous, is cast aside; the little leaves rack and stretch themselves, and joyfully spread themselves out in the air and light; the little stalk grows longer and longer; in a little while the buds have shot out into young limbs, in the fresh foliage of which, excited by the light of the sun, the restless labor of the cells begins anew; or, after a marvelous transformation into flower-stalks, they produce those sexually developed procreative cells which are destined by a series of mysterious processes to found a new cell-state.

Thus is the cell-state of the plant subject to a continual rejuvenation. The individual citizens (the cells) and the villages (the leaves) have but a short life, but the state in its entirety may endure for centuries in lasting youth. If the hands of men, or the elements, do not inflict a violent death, the cell-state, as so many primitive giant trees have shown, may outlast the mightiest kingdoms of men.

Gifted writers on social politics have recently endeavored to illustrate the development and interrelations of human society by analogy with a living being and its cells. We have taken the converse course, and have endeavored to make the life of the plant and its cells comprehensible by a similitude with a state organization and its citizens. We have endeavored to show that what man has regarded as the highest ideal of his conscious effort in the struggles of the world's history has been prefigured in quiet accomplishment in the world of plants.

It is the representative of the idea of the state which leaves its individual citizens to develop themselves freely according to their inborn natures, and to work together on an equal footing for the good of the whole; which preserves to the villages and the provinces their self-administration, and yet subjects them in every instant to the higher interests and laws of the whole; which appears ready armed against the external enemy, preserves unity and peace within; which applies the capital accumulated by the common labor of all the citizens to the advantage and advancement of the whole, without letting it be preyed upon by any; which in untiring activity never suffers a pause, and by continuous renovation endures for centuries, always increasing, always blossoming, and always bearing fruit.

AMERICAN AND FOREIGN ASPHALTS.

By E. J. HALLOCK.

BITUMINOUS substances, apparently of organic origin, are found in various parts of the world. Sometimes they occur in a free state, as in the Island of Trinidad, and at others impregnating calcareous rocks, or serving as a cement to hold the particles together, as at Val de Travers or Seyssel.

For several reasons the asphalt lake in Trinidad possesses special interest for us. The island, which is the southernmost of the Lesser Antilles, lies off the northern coast of South America, and is easily accessible from any of our sea-ports. Here, amid the most luxuriant vegetation, is a lake three miles in circumference, on the surface of which lies a crust of asphaltum of such tenacity that in the rainy season a person can walk across it; but, under the influence of the hot sun, it softens to a thick tar. This crust receives accessions from beneath, and formerly it would overflow and run into the sea, more than two miles away. A similar substance, known as "Jew's pitch," is washed ashore in considerable quantities around the borders of the Dead Sea. In Texas, south of Shreveport, there is said to be a pitch-lake containing large quantities of bitumen, but little is yet known about it. In Southern California there are accumulations of asphalt on the coast at Santa Barbara, San Luis Obispo, etc., which resembles, when pure, that from Trinidad. It promises to supply the wants of the western coast, as Trinidad will that of the eastern part of this country.

In Kentucky there is a considerable quantity of asphaltic mineral which may some time be utilized for road-making.

An interesting and valuable asphaltic mineral, known as Albertite, is found in New Brunswick; and a similar one, called Grahamite, oc-

curs in West Virginia and other parts of the country. In the mountains west of Denver, in Colorado, is a vertical bed of hard and brittle asphalt, not unlike Grahamite, while Albertite is found in small quantities in Lorain County, Ohio, and Casey County, Kentucky.

Bitumen is likewise found in Cuba, and is brought into commerce under the name of *chapopote*, or Mexican asphalt.

In Europe asphalt occurs chiefly in limestone, which forms, when crushed and packed, an excellent pavement. The principal points at which it is found are the following: Val de Travers, in the Swiss Canton of Neufchâtel, fourteen miles from Neufchâtel, and sixteen or seventeen miles by rail from the French borders; Seyssel, on the Rhône, in the French department of the Ain, about thirty-three miles from Geneva; Lobsann, a small town in northern Alsace; Vorwohle, in Braunschweig; and Limmer, near the city of Hanover. The Italian province of Caserta, in the neighborhood of Naples, supplies Rome with an asphalt much used for terraces and flat roofs.

The quantity of bitumen in these limestones and the manner of its dissemination are quite varied, but it is generally found that the softer limestones contain more bitumen than those which are harder. The average amount is about ten per cent, but it sometimes reaches twenty or thirty per cent, and occasionally there are cavities in the rock which are filled with bitumen. At other times the quantity sinks to five per cent, or less, while nodules of limestone entirely free from it are also found. The value of the rock depends on the percentage of bitumen, and on other circumstances. If the stone is to be used for making mastic, the higher the percentage the more valuable it is; but, if used directly for paving, a uniform distribution, not exceeding eight or ten per cent, is desirable.

Asphalt-stone, to which Malo limits the name of *asphaltum*, varies in color from gray to brownish-black, according to the richness in bitumen; that of medium quality closely resembles chocolate in color. That which is poor in bitumen is hard, and rings like ordinary limestone; but the fatter rock, when struck with a hammer, gives forth a dull thud, like a block of wet plaster, and takes an impression from the blow. If it contains more than ten per cent, it crumbles in the hand, and can be cut with a knife, like chocolate. Good stone, with about ten per cent of bitumen, has a specific gravity of 2·1. Some asphalt-stone is of a spongy, hygroscopic nature, and consequently lighter.

One peculiarity of the natural rock-asphalt is that, when heated over a fire, it breaks up into a brown powder, and then, at a higher temperature, all the bitumen is expelled, leaving a pure white powder. An unsuccessful attempt was made in the Paris Conservatoire des Arts et Métiers to imitate this asphalt-stone by forcing thick, pasty bitumen into pure limestone by great pressure. When, however, the lime-stone was boiled for a long time in a liquid mass of asphalt, it

became so completely saturated with it that the innermost fractures resembled the natural asphalt-stone; but it differed from the latter in this most important property, that it did not crumble to a powder when heated. On the contrary, the absorbed bitumen was expelled by heat, leaving a hard limestone, instead of a calcareous powder. From this it seems probable that the particles of the natural asphalt-stone are simply cemented together by the bitumen, and both must have been deposited at the same time.

In most mines the strata dip slightly toward the horizon. They vary greatly in thickness; sometimes there is only one stratum, at others there are several superimposed on each other or separated by strata of harder limestone or shale. At Val de Travers the strata that are worked are from two to six metres thick, and rest on hard, non-bituminous limestone.

In some places it is mined in open trenches, in others by means of shafts and subterranean tunnels. At Val de Travers, Seyssel, and Lobsann, the latter alone are employed. The rock is blasted out with powder, which works better in soft rock than dynamite. The holes are bored with an ordinary hand-auger. At Limmer, owing to the water in the mines, it is necessary to use dynamite.

The percentage of bitumen in the different varieties of asphalt-stone is as follows: That from Limmer, 14·3; Val de Travers, 10·15; Lobsann, 12·32; Ragusa, 8·92; Seyssel, 8·15; Vorwohle, 8·50. It is estimated by extracting it from the finely pulverized mineral with carbon disulphide, benzene, or other solvent, and weighing the residue after the solvent has evaporated. The quality of the bitumen is determined by heating it to 430° or 440° Fahr.; the less it loses by evaporation the better its quality. The powdered mineral from which the bitumen has been extracted should be white and soft. If it has a gray color, and feels harsh or sticky, it is of poor quality. Too much dependence can not be placed on chemical analyses, for much depends on the physical properties as well.

The larger portion of the asphalt-stone used in Europe comes from Val de Travers, which produces about 25,000 tons a year; Limmer is not much inferior in its yield, which amounts to about 21,500 tons; Seyssel furnishes 13,000 tons, and Lobsann about 9,000 tons. That which is mined at Limmer and Vorwohle, being very rich, is only used for making mastic.

The first operation to which the asphalt-stone is subjected, when it reaches the factory, is pulverization. For this purpose several different machines are in use, the ordinary stone-breaker being unsuited to the purpose. Four or five of these are figured in Professor Dietrich's new work on "Asphalt Streets,"* to which we are indebted for many of the facts in this article.

The powder thus obtained may be employed directly for the com-

* "Die Asphalt-Strassen," E. Dietrich, Berlin, 1882, pp. 207.

pressed asphalt pavements, or converted into "mastic" by mixing it with one tenth to one seventh its weight of purified bitumen from Trinidad and cooking five or six hours. It is then poured into cast-iron molds without bottoms, which are placed on the sanded floor of the shop. These blocks of mastic are fifteen inches in diameter and four inches thick, weighing fifty or sixty pounds each. Those made at Val de Travers are hexagonal in form, bearing a trade-mark of a cross and $\frac{V}{T}$; those from Seyssel and Lobsann circular; the others oblong, with rounded corners.

The Val de Travers mastic and asphalt rock are imported by the Neufchâtel Asphalt Company (54 Astor House, New York); the Seyssel mastic by the New York Mastic Works (35 Broadway); the Limmer and Vorwohle rock asphalt by C. Wichtendahl (111 Broadway, room 97). In regard to their uses in this city we shall speak more fully in another place.

Trinidad asphalt is imported and refined by the Warren Chemical and Manufacturing Company (45 John Street). This substance, as it occurs in nature, is very impure; about one third of the mass consists of water, another third is made up of clay and sand, so that only one third is actually bitumen. It is melted in large kettles and heated for twelve hours to expel the water, the earthy constituents settling to the bottom. This partially purified asphalt, which still contains about twenty per cent of impurities, is poured through a sieve into barrels, where it solidifies. It now forms a brittle mass, which sells for twenty-five dollars per ton. It is too hard for mixing with the pulverized asphalt-rock, or for street pavements. At Val de Travers and Seyssel the residues from the distillation of bituminous shale, known as "shale-grease," are used to soften it, while in other places similar residues of paraffine manufacture or petroleum refining are added to the natural bitumen to form what is known as "prepared bitumen," or mineral tar. In this country the so-called "still-bottoms" from petroleum-stills are used in the proportion of fifteen parts of the latter to eighty-five of the natural asphalt; the portions may be varied to suit the climate and other conditions.

Asphalt pavements may be divided into three classes. The first, which is commonly known as mastic (*asphalte coulé*), is best adapted to sidewalks, court-yards, and other places where there is but little heavy traffic. It is prepared by melting the blocks of mastic, already described, in caldrons, adding a small quantity of prepared bitumen, and afterward stirring in thirty or forty per cent of clear grit. When thoroughly mixed it is carried to the spot in pails, and spread with a wooden float by a skilled workman on his knees. It is then rubbed until perfectly smooth, and fine sand strewed over it. Examples of this pavement can be seen in Union Square, Tompkins Square, and several other places in New York city.

Compressed asphalt is better adapted to heavy traffic, as in street

pavements, and is much employed in Paris. The powdered rock is used without any addition. It is applied hot, on a prepared bed of concrete, four to seven inches thick, and compressed, with heated rammers and a heated roller, to the thickness of one and a half or two inches. The smooth surface is given by a heated smoothing-iron. One block of compressed Val de Travers asphalt, two inches thick, laid on a Portland cement concrete foundation seven inches thick, may be seen on Fifth Avenue, between Twenty-sixth and Twenty-seventh Streets.

The third form of pavement, which seems to be one of the best for roadways, is the "Trinidad." It is made of prepared bitumen, i. e., Trinidad asphalt and still-bottoms, mixed with about twice its weight of calcareous marl or powdered limestone. None of the imported asphalt mastics or rock are used in this pavement.

Various imitations of both asphalt and mastic have been palmed off on the public, or substituted by dishonest contractors, some of whom will keep a few blocks of real mastic of a well-known brand lying about, as if they were to be used, while inferior materials are thrown into the caldrons. Some imitations are but little inferior to the genuine, while others are nearly worthless, and have done much to bring asphalt into disrepute. Among the latter are those made in whole or in part of the pitch left in the distillation of coal-tar. Although useful for a great variety of purposes, it will not answer for asphalt pavements. It is usually possible to distinguish good bitumen by its smell when warmed. When heated with excess of concentrated or fuming sulphuric acid for twenty-four hours, and then diluted and filtered, the pure natural bitumen yields a nearly colorless solution, but if pitch is present the solution will be dark-brown or black. Another distinction between real bitumen and coal-tar is found in the solubility of the latter in alcohol, the former being nearly insoluble. If a grain of material that has been heated to 200° C. is pulverized and mixed with 5 c. c. of strong alcohol, the latter will acquire a yellow color and bluish-green fluorescence if there is more than two per cent of pitch present.

There are several uses to which asphalt may be applied, the most important being the one already so often referred to, namely, as paving material. In Paris about thirty-three miles of street are covered with asphalt pavement, more than three fourths of it being the so-called "compressed asphalt," while the remainder is made of cast or mastic asphalt. The use of asphalt pavements for roadways began in Paris in 1854, since which time their use has been steadily increasing until the present time. In London there are about nine miles of asphalted streets. Asphalt pavements have but recently begun to find favor in Berlin, and at the close of 1881 there were only six miles of street paved with it. Of asphalt sidewalks, etc., Paris has three million square metres, equivalent to four hundred miles of walks, seventeen feet wide.

New York city can boast of only a few small and isolated strips of asphaltic street pavement, her past experience with the "poultice-pavement" having induced the authorities to prohibit the laying of similar pavements. In front of the Brevoort House, and the Hotel Brunswick, samples of compressed pavement may be seen, while the American mastic, or Trinidad, has recently been laid in Fifteenth Street, between Fifth and Sixth Avenues. In Washington, D. C., more than forty miles of the last-named pavement have been put down, and it is said to be doing good service. There are a large number of the mastic sidewalk and court-yard pavements in this city, some of which have already been referred to.

The advantages claimed for asphalt pavements are cleanliness, noiselessness, and durability, while the wear and tear of horses and wagons is less, and they are the pleasantest of all pavements to ride on. On the other hand, they are often slippery, and horses are liable to fall on them, while they are more difficult to repair when broken in digging for water and other pipes, although it is said that water-pipes are less liable to freeze under asphalt than under other pavements.

Asphalt does not emit sparks when struck with steel, and therefore is useful for the flooring of powder-magazines, and of casemates in fortifications.

As damp-proof coating for vaults and cellar-walls it is invaluable, for, not only does it shut out damp from below, but prevents unhealthy exhalations of the soil from entering the dwelling.

Asphalt has been used as flooring in stables, although there has been some complaint that it is cut by the stamping of the animals. It would seem to be an excellent material for the purpose, as it is unacted upon by urine, and, being without cracks, prevents the liquids from passing through and saturating the earth beneath. It is in use in the stables of the American Horse Exchange, Fifty-sixth Street and Broadway.

Asphalt floors have found more extensive use in breweries and sugar-refineries, for which they seem perfectly adapted. It is frequently applied to cellar-bottoms in city houses, some careful citizens having covered their cement floors with asphalt mastic.

A method of laying floors is much used in France, for barracks and hospitals, which would probably answer for many other purposes. Pieces of oak, usually two and a half to four inches broad, twelve to thirty inches long, and one inch thick, are pressed down into a layer of hot asphalt, not quite half an inch thick, in herring-bone pattern. The edges of the blocks are planed down, beveling toward the bottom, thus insuring adhesion to the asphalt, and the smallest possible joints.

A coarse sort of canvas saturated with bitumen is used to prevent dampness from rising through capillary attraction and penetrating the walls of buildings, especially light-houses and marine structures. It is

made in strips twelve, sixteen, twenty, or twenty-four inches wide, to correspond with walls made of three, four, five, or six courses of brick. Its superiority to ordinary bitumen depends on the fact that it will not crack, like the latter, from unequal settling of the walls. Damp-resisting solutions are also sold for coating damp walls.

Asphalt mastic is much superior to tar for roofing purposes, owing to its *fire-proof* qualities, and its use for this purpose is rapidly increasing. At the present writing it is being applied to the Welles Building, at the lower end of Broadway. It is said that, when a building covered with such a roof burns, the falling roof acts like a blanket in smothering and extinguishing the flames.

Asphalt possesses another valuable property, that of absorbing vibrations, and is hence useful for foundations of machinery running at high speeds. A block of bituminous concrete weighing forty-five tons formed the foundation of the Carr's disintegrator which made fourteen hundred revolutions per minute at the Paris Exhibition. It would seem to be especially adapted to serve as foundations for the high-speed steam-engines used for generating electricity.

Asphalt forms an excellent insulator for electricity, but, as other and cheaper materials may be employed, its use will not be so extensive in this field.

The origin of asphalts is unknown, but several theories have been advanced in regard to it. Professor J. S. Newberry believes that they are the more or less perfectly solidified residual products of the spontaneous evaporation of petroleum. If we accept this theory (and many do not), we are but one step nearer a solution of the problem, for the origin of petroleum itself is still unknown. Some think that the bitumen was formed first, and the limestone deposited in it; others, that the liquid bitumen was forced into the pores of limestone already in existence; while a third hypothesis assumes that they were formed simultaneously, the bitumen from the organic matter, and the lime from the shells of some ancient mollusks. The last-named theory seems to have some support in the abundance of fossil ammonites met with in the mines at Limmer; the experimental attempts to impregnate the rock artificially, as above described, render the second hypothesis improbable, although its occurrence on the Dead Sea and in Trinidad is in its favor. No explosive gases are met with in the mines of Val de Travers, Seyssel, and Lobsann, so that open lights are used; but at Pechelbronn, a few miles from Lobsann, several explosions have occurred. Although these were attributed to marsh-gas, they were more probably due to the vapors of the lighter constituents of petroleum, with which the bituminous sands of that locality seem to be saturated.

There are several circumstances which indicate that bitumen and asphalt are more nearly related to petroleum than to coal-tar, and that, whether asphalt was made from petroleum or not, they have a similar

or common origin. Nor is it an unfortunate circumstance that coal-tar can not be used as a substitute for bitumen, since the former contains many constituents that are more valuable for other purposes, while Trinidad offers an inexhaustible supply of the latter.

SPECULATIVE ZOÖLOGY.

By Professor W. K. BROOKS,
of Johns Hopkins University.

I.

AT a time when most naturalists who venture at all beyond the facts of life-science are busied with the attempt to trace the relationship between the various groups of living things, and to express this relationship in a tree-like system of classification, it is startling to hear from one of the highest authorities on life-science the statement that "the time for genealogical trees is past. . . . It seems hardly credible that a school which boasts for its very creed a belief in nothing which is not warranted by common sense should descend to such trifling." *

It is true that the context seems to show that the author does not visit all attempts at phylogenetic classification with the sweeping condemnation which the passage quoted seems to imply, yet the fact that a high authority upon the subject has made such a statement at all is a sufficient reason why those who believe that the status of modern morphology is not without a basis of common sense should carefully revise their grounds for this belief, in order to decide for themselves how far, and in what shape, such speculations upon the relationships of organisms are admissible, and favorable to the progress of science.

The belief that the present life of the globe is only a very small part of its total fauna and flora is hardly more firmly fixed in the minds of the present generation of naturalists than the belief that the recent species are the modified descendants of those which are extinct; and there are few who would not acknowledge that their conception of the origin of life would be fairly illustrated by comparing the living things of the past and present to a great, many-branched tree, buried in the ground so that only a few scattered groups of twigs are exposed to our direct observation, although these groups show by their arrangement a vague and indefinite relation to the branches below the ground. The twigs which are exposed are the living things which now people the earth, and those twigs and branches and larger trunks which

* "Embryology and Paleontology," by Alexander Agassiz. Address before the American Association for the Advancement of Science.

are below-ground are those organisms which are buried in the past, and which we can study only through their fossil remains.

Most naturalists not only believe that, if we could trace back the history of life, we should find each group bearing evidence of wider and wider relationship as we receded from the present time, but they also believe that we should ultimately find that every form of life is related to every other in such a way as to show that, in the remote past, they all met in a single starting-point—the common ancestor of all living things.

When we come to examine the evidence for this theory of the common origin of all life, we find that it is almost entirely general in its character. There is a nearly complete absence of specific and definite proof. We find an abundance of fossil forms, which we may regard as connecting links between one great group of animals and another; but even in the most favorable cases the attempt to follow the history of any particular species back for a considerable length of time soon ends in a total failure, for we lose track of its line of descent entirely, and can go on only by substituting, for the species with which we started, the genus, family, or more comprehensive group to which we have traced it.

Once in a while we find, in the later geological formations, a fossil animal which exhibits such affinity to several closely related recent species, that there is a strong presumption that it is the common ancestor from which they have descended. We have enough evidence to enable us to trace the horse and its allies through several geological periods with considerable accuracy, and to reach a form which is widely different from the horse, and which shows relationship to quite different groups of recent mammals. There are a few other cases where the evidence is equally abundant; but more usually it fails completely, and, although the fossils of the later formations show a very close relationship to their living allies, the resemblance is not exact enough to prove that the fossil forms are the direct ancestors of the recent ones, rather than more distant relations, connected by some unknown fossil form.

In place of the exact evidence which would be necessary to prove that the nearest fossil allies of recent species are in the direct line of descent, we have only the vague general evidence which is furnished by those fossils which unite in themselves the characteristics of widely separated families, or classes, or orders of animals. While the attempt to trace any particular species of bird and any given species of reptile to a common ancestor would be hopeless, we do find fossil organisms in whose structure certain general characteristics of the class Birds are united to certain general characteristics of the class Reptiles, in the way which we might expect if those animals are the descendants of true reptiles and the ancestors of the true birds of the present day. There is no proof that this actually is the case, and it is perfectly

possible that they are not in the direct line of descent at all. The evidence is entirely circumstantial and indefinite, and it is impossible to show that any of the reptile-like birds which have been discovered have any descendants at the present day. All we can say is that, if our birds are not their descendants, it is very probable that they are the descendants of some other unknown form very much like them.

At the best it is simply a question of probability, not of direct proof, and paleontological evidence is never definite enough to enable us to reach a specific conclusion which may not possibly be wrong, and, this being the state of the case, we may fairly ask whether such speculations upon probability, in the absence of direct evidence, are entitled to be called science. In order to answer this question, and to show that phylogenetic speculation may be strictly within the legitimate scope of science, we will make use of an imaginary illustration.

Suppose that a large continental area, which is inhabited by a homogeneous human race, is invaded by a band of settlers from another country, about as the first European settlers forced themselves upon the homogeneous inhabitants of the United States.

Suppose that these settlers, increasing in numbers, gradually spread over the whole country, interbreeding with the autochthones, until, in later generations, the population comes to consist of two equally distributed races, represented by individuals of pure descent, with strongly marked race-characteristics; and, in addition to these, a great number of hybrids, presenting the characteristics of the two pure races in all degrees and manners of union.

As time goes on, imagine this latter class to increase at the expense of the others, until few persons of pure blood are left; and meanwhile suppose that a number of persons of a third race are introduced, about as the negroes were introduced into this country, and, after this immigration has lasted for a time, suppose it to stop, and let this third race spread and increase, and, after a time, gradually mix with the other two. Let the same process take place again, until the population comes to be made up of four quite dissimilar races with well-marked race-characteristics, crossed in such a way that no individuals of the original race or of the first immigration are of perfectly pure blood, while there are a few nearly pure types of the third race, and still more of the fourth. Suppose, now, that an anthropologist undertakes to study the inhabitants of the country in order to learn what he can of their origin and history, and let him begin by attempting to classify them. Any attempt to divide them up into groups will fail, on account of the complexity of their relationships; and, although there are traces of four types, it is not possible to arrange them in four classes, since most of them have resemblances to more than one type. After long study of their relationships, and an enumeration of all the forms which are distinguishable, we may suppose him to hit upon some such expe-

dient for tabulating their resemblances as that of arranging them in four intersecting sets of concentric circles.

One type, the latest arrival, would be represented by a series of larger and larger circles around a center—the center standing for the few individuals of pure blood; the next ring, overlapping the other sets a little, would represent those persons, more numerous than the pure specimens, in whom the characteristics of the race are slightly obscured by characteristics of the other types. The next still larger ring, intersecting still more rings in the other sets, represents the still greater number of individuals of less pure descent, and so on; each larger circle, intersecting the other sets at more points, will represent the manner in which the number of individuals increases as the purity of the type disappears.

The race which has been a little longer in the country will, if it has been equally prolific, and equally inclined to mix with the others, be represented by a system with no center, but with a few very small rings so near the center that they have few points of intersection with the other sets—that is, there will be a few persons with nearly pure blood, but none of perfect purity. The two older races will be represented by systems which are made up entirely of large intersecting circles. After his studies have carried him thus far, we may suppose the anthropologist to speculate how or why it is that the complicated resemblances of this mixed people should follow a system which admits of such a peculiar system of tabulation. He might perhaps invent an hypothesis to explain it—the hypothesis of immigration. As this hypothesis would account for all his facts, there would be a probability in its favor sufficient to justify him in following it out as far as possible, to see what it would lead to, and we may suppose him to continue his studies historically. He would now find that the number of pure specimens of the race which entered the country last was greater a few generations back than at present, while the number of persons who exhibit only slight traces of the characteristics of this race become less numerous as he traces the history backward. Going still further back he would find that the pure-blooded specimens of this race not only become more numerous in proportion to those of mixed blood, but also more restricted in their distribution over the country.

Still farther back he would find records of the entrance of a few perfectly pure representatives of this race into the country, and, continuing his studies, he would meet with no evidence of the presence of any of them before this date.

Continuing his studies he would find that the second race gradually became more pure and more restricted, and, although he might not meet with any record of their first appearance except vague and contradictory traditions, he would find that there was no mention of them in any of the records before a certain date. The older monu-

ments and records would contain references to only two races, and, although there might be no traditions to show that either of these had occupied the country longer than the other, the history of the language and the architectural and other remains would bear witness to the gradual introduction of one of them, and would show that in still more ancient times there were no traces of the existence of more than one race.

The interpretation of the relationships of the people to which he had been led by the study of the living inhabitants would now be far more than a working hypothesis, for everything which had been learned about their past history could be shown to be exactly what we should, by the hypothesis, expect, and he might therefore claim that this was a strictly scientific explanation of the theory of their origin. Although he would have definite proof of only one immigration, he would be fully warranted in concluding that the present inhabitants are the result of the crossing of four races; that at one time only one of these races inhabited the country, and that the other three have been introduced from outside at different times in a definite order.

The mass of evidence which he could bring forward in favor of this opinion would be sufficient to render it more probable than any other explanation of their origin, and would fully justify its acceptance as a scientific truth, but a little examination will show that the evidence is entirely circumstantial, and does not by any means amount to absolute proof, but only to a very great degree of probability. Although it may be true that it is very much more probable than any other explanation, this may be due to imperfect knowledge, and some other explanation may possibly be the true one.

In order to show this, let us suppose that the people of the country have another account of their origin, and believe that the four types were formed ages ago by the breaking up of an homogeneous race into four castes, which have ever since borne substantially the same relations to each other. Suppose that this belief bears such a relation to other traditions, and to certain manners and customs, that it has assumed, in their minds, a very great importance, and is regarded as a point of grave significance, resting upon irreproachable evidence. They might answer the anthropologist somewhat in this manner: You have certainly made out a very ingenious story, and have brought together a mass of evidence which appears to render your view very probable, but you have not shown that no other explanation is possible, and, as we do hold quite a different opinion upon evidence which is satisfactory to us, you must be mistaken. We are open to conviction, and are not unreasonable, but we must have proofs which leave no room for doubt, for as long as there is a chance that you are wrong we must hold to our old view. If you say that all natural knowledge is simply probable, and open to the possibility of error, give us proofs

which are as direct as those which are furnished by the physical sciences, instead of the general and circumstantial evidence which you adduce. The student of physics does not ask us to believe that all bodies attract each other according to the law of inverse squares until he has shown us that he is able to prove that every body we bring him does behave in this way; and the chemist shows us that he can separate every specimen of pure water which we furnish into oxygen and hydrogen before he expects us to believe that all water is compounded of these two substances. This is the sort of proof we want; something exact and specific in place of your generalizations. When you can trace back the ancestry of any man we bring you with what you call negro characteristics, tell us who his father and grandfather were, and so on, until you reach one of your negro immigrants—when you can do this with all our inhabitants, and show us that every man with these characteristics is the descendant of one of these immigrants, and that every man with European characteristics has some of the blood of one of your European immigrants in his body, you may claim that you have given us scientific proof of your hypothesis.

If that is too much to ask, trace one of our people back in this way, for it must be plain to you that, if you are not able to do this, your hypothesis is only a probability.

You trace us back for a generation or two with some exactness, but then you make a great leap to some one whom you find mentioned in history, and you trace his ancestors and descendants for a generation or two, and then comes another break. There is no certainty that he has any living descendants, nor is there any certainty that he is at all related to any of your immigrants. We acknowledge your proofs of a negro immigration, and we know that a few other negroes have come to our country from time to time, but their race soon dies out, and you must remember that we have satisfactory evidence that our race had its present character long before the time when you say the foreign elements were introduced.

Even if we grant the accuracy of all the facts which you claim to have discovered, they only show that the history which you have traced out is such a history as your hypothesis would lead you to expect, but this does not prove the truth of the hypothesis. You have only got at a few facts here and there, and future discoveries may show that you are wrong. We are glad to know about the foreign settlers, but you have by no means proved that they were ancestors of ours.

I think that this illustration gives us a fair statement of the value of the evidence for evolution which is furnished by paleontology. There is an absolute and total lack of direct proof, and there must be by the nature of the case, so there is no room to hope for the conversion of any one who is determined to reject the theory as long as doubt is possible; but the end of science is not to proselyte but to dis-

cover, and the circumstantial evidence converges in such a way as to give in this case every assurance of substantial accuracy.

There is not a single wild species of animal which can be traced, by direct unbroken pedigree, to an ancestor belonging to a different genus, and no zoölogist has any hope of ever obtaining anything more than circumstantial evidence of such a pedigree; but we can hardly overestimate the vast and increasing stores of evidence in favor of evolution which are yielded by the structural, geographical, and chronological relations between the fauna of the present day and that of the past. It is true that all this evidence is circumstantial, and, although it renders the theory of evolution vastly more probable than any other explanation of the origin of species, it still leaves a possibility that some other explanation may be the true one. Although the investigator who is fully acquainted with all the evidence may feel justified in ignoring this possibility, it still exists.

If the evidence which we have is so circumstantial that it does not amount to absolute proof, it is clear that, even if we fully believe in evolution, we can not hope to trace, with anything like minute accuracy, the past history of any particular form of life; but perhaps an illustration may help to make this clearer:

Let the dots A, B, and C (Fig. 1), represent a number of recent species, each of which has distinctive characteristics of its own, together with other characteristics which are common to all; and let D, E, and F be another set of species related to each other in the same way; and suppose that certain of the common characteristics of D, E, and F are also common to A, B, and C, while others distinguish the one set as a whole from the other as a whole. According to the theory of evolution, we believe that A, B, and C are the descendants of an ancestor from whom they inherit all that they have in common; and that D, E, and F are related to each other in the same way; that the common ancestor of all the forms in the first group had, together with distinctive characteristics of its own, certain other characteristics which it shared with the ancestor of the forms in the second group, and that this similarity was due to inheritance from a still more remote ancestor common to both. This system of relationship might be expressed by a phylogenetic tree, like that which is shown by dotted lines ..... in the diagram, with six ultimate ramules, two large branches, and a common stem, G. Now, suppose that we discover, in a recent geological formation, a fossil form, M, which resembles A, B, C, D, E, and F in all the features which they have in common. It is possible that this fossil is the form G, from which A, B, C, D, E, and F are descended, but it is not probable that this is the case, for the analogy of recent species compels us to believe that the fossil M was one of several closely related species, G, H, I, K, and L, any one of which may have been the ancestor of the recent forms, and, as M is only one out of several species, the chances are that it is not the root G from which

A, B, C, D, E, and F are descended. Even if it could be proved to be the only species of its genus, and therefore the direct ancestor of the recent species, the precise manner in which these are related to it would still remain in uncertainty, for it may have given rise, at about the same time, to two divergent variations, represented by the dotted lines, and these may have led to the two forms *a* and *b*, each of which gave rise to variations which resulted in the recent species A, B,

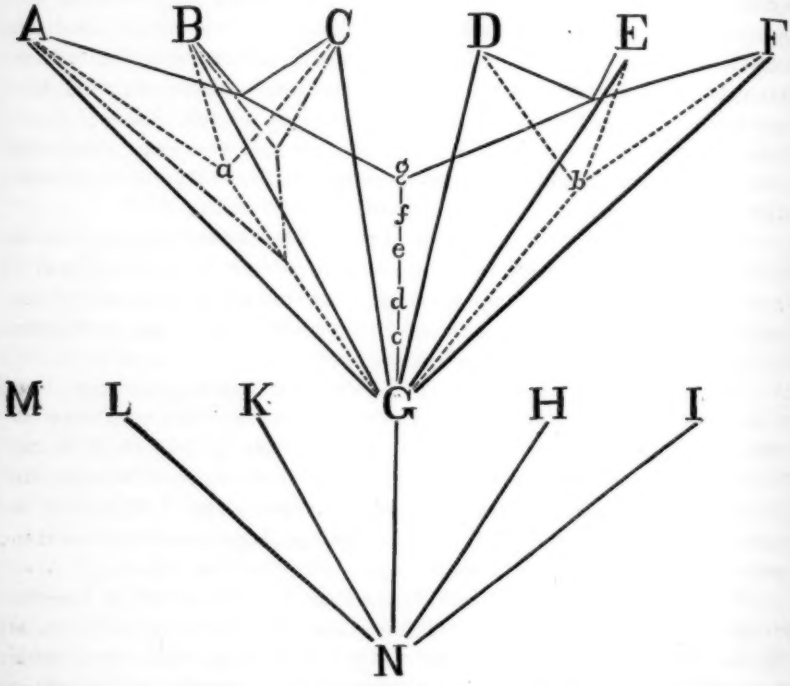

FIG. 1

C, and D, E, F, or it may have persisted for a long time, and become slowly modified, through the stages *c*, *d*, *e*, *f*, into the form *g*, different from the form G, and still more different from the known fossil M, before it gave rise to the ancestors of the two recent genera. In this case the phylogenetic tree would be represented by the continuous light lines of the diagram. It is possible, again, that A, B, and C are not equally related, but that two of them, B and C, for instance, have had a common ancestor which was not in the line which led to A, and in this case their relationships would be expressed by the broken lines —.—.—.— of the diagram; or, finally, it is perfectly possible, and many naturalists think it is very probable, that evolution has been guided by some more fundamental law than that of the natural selection of divergent variations, and, if this is so, the characteristics which distinguish A, B, and C may be due to something else

than descent from a common ancestor, *a*, different from the common ancestor *b* of D, E, and F, and all may be the descendants of G, in the way shown by the heavy lines, or A may be the descendant of I; B of K; C of G, etc. If we were to attempt to indicate all the possible ways in which the six living species, A, B, C, D, E, and F, may be related to the fossil M, the diagram would become a confused mass of lines, and we have pointed out enough to show that, in a very simple case, where there are only two living genera and only six species, the attempt to follow them back only two stages to a common ancestor leads to so many possible systems of relationship that there is a very great chance against the truthfulness of any particular one, and we may fairly ask whether the attempt to express the relationships of animals in a tree-like classification can have any scientific value if the chances against its correctness are so very great. At first sight it may seem as if no good could be expected from this sort of speculation, and we may feel inclined to condemn the construction of phylogenetic trees as unscientific; but a little examination will show that all the lines in the diagram agree in one important particular, and trace the recent animals, A, B, C, D, E, and F, back to a remote common ancestor with a general resemblance to M. This, after all, is the essential thing, the gist of the whole matter, for the precise line of descent has no more scientific interest than the exact pedigree of each person would have to the anthropologist of our illustration. Such an exact pedigree would have a certain value as a bit of specific information, but the general evidence is of such a character that it is more logical to accept the conclusion than it is to reject it, and it is as truly scientific as the conclusion of our anthropologist.

We find that living things are related to each other in a peculiar way, which can be explained upon the assumption that they are the modified descendants of more ancient generalized forms, with wider relationships, and this assumption can be readily expressed in the form of a phylogenetic tree. We find, too, that so far as the higher groups of vertebrates, the mammals, reptiles, and birds, are concerned—groups which are of comparatively recent appearance, like the last races of immigrants in our imaginary case—the fossil forms which we meet with are such as our assumption would lead us to expect. The presumption is, therefore, very great that the genetic relations of living things may be expressed with general accuracy by a phylogenetic tree, although the chances of minute accuracy of detail in favor of any particular tree which is drawn up from paleontological evidence are very slight. This lack of minute accuracy can not be urged as an objection to all attempts at following out, in a general way, the lines of evolution of our present groups of animals, according to the best evidence which is attainable, and we must remember that only a very small part of this evidence is furnished by paleontology. If no fossils were known, the facts of comparative

anatomy, of embryology, and of geographical distribution would be enough to satisfy us that the living things known to us are the divergent descendants of more generalized ancestors, and that their relationships can be most exactly expressed by a system of converging lines, which meet and form larger branches to represent the extinct ancestors from which our divergent species are descended. The evidence is circumstantial, and only leads to general conclusions, and a complete series of fossil forms is the only absolute proof which we could have; but, in the absence of this proof, the conclusions drawn from the study of living animals are rendered extremely probable by the fact that the fossil members of the more modern groups of animals, such as the mammals and birds, are just such forms as the evidence from other sources leads us to expect, and the attempt to read and interpret such records as we have, and to trace the history of life with as much accuracy as possible, is therefore perfectly legitimate, and may fairly claim the attention of the morphologist.

ANNUAL GROWTH OF TREES.

By A. L. CHILD, M. D.

ARE the concentric rings of a tree a reliable record of its age in years? Such has been the conception—in fact, the undisputed knowledge—of the world, for all time past. I have no recollection of ever having seen or heard the authority of this record disputed till Désiré Charnay, in his "Ruins of Central America," said, when speaking of the age of the ruins as proved by such a record: "Unfortunately for the argument, it is altogether fallacious and proves nothing. I have put the evidence to a test. On examining a slice of wood of a shrub that I knew as a fact was only eighteen months old, I found that it had eighteen concentric rings. I thought it was an anomaly, but, in order to convince myself, I experimented upon trees of all kinds and sizes, and invariably found the like result produced in very nearly like proportions." *

M. Charnay's statement was, in my estimation, rather loose, and lacking in the proof of his absolute knowledge of the age of the trees examined; and again, so far as applicable to the case, was only so in a tropical climate, where the conditions were entirely different from those surrounding us in a higher latitude, and altogether raised but little doubt on the subject.

In April of 1871 I planted a quantity of the seed of the common red maple (*Acer rubrum*). In transplanting, in 1873, they were placed too near each other, and it has become necessary to cut a part

* "North American Review," September, 1881, p. 401.

of them out. While cutting, I noticed that the concentric rings were very distinct, and it reminded me of M. Charnay's statement. I took sections from the butt-end of each tree (four of them) and dressed the ends off, at an angle of some 35° with the line of the body, thus largely increasing the exposure of each ring, and then counted them.

The situation, exposure, and condition of these four trees were, so far as I could see, identical. I had personal and positive knowledge that they had each twelve years' growth upon them, and I could count on each of the different sections from thirty-five to forty concentric rings. True, I could select twelve more distinct ones between which fainter and narrower, or sub-rings, appeared. Nine of these apparently annual rings on one section were peculiarly distinct, much more so than any of the sub-rings; yet, of the remaining, it was difficult to decide which were annual and which were not.

The thickness of these annual rings varied from two and one half millimetres to twenty-eight. This measure, of course, gave more than double the real thickness; but was preferable to a right-angled measure, as it gave better facilities for exactness, and yet preserved the proportion between the several rings unchanged.

Now, to ascertain what relation or connection there might be between the meteorology of

YEAR.	MARCH.				APRIL.				MAY.				JUNE.				JULY.				AUGUST.				Mean temperature of six months.	Total rain of six months.	Growth of wood in millimetres.
	Maximum temperature.	Minimum temperature.	Mean temperature.	Rain-fall.	Maximum temperature.	Minimum temperature.	Mean temperature.	Rain-fall.	Maximum temperature.	Minimum temperature.	Mean temperature.	Rain-fall.	Maximum temperature.	Minimum temperature.	Mean temperature.	Rain-fall.	Maximum temperature.	Minimum temperature.	Mean temperature.	Rain-fall.	Maximum temperature.	Minimum temperature.	Mean temperature.	Rain-fall.			
	Deg.	Deg.	Deg.	In.	Deg.	Deg.	Deg.	In.	Deg.	Deg.	Deg.	In.	Deg.	Deg.	Deg.	In.	Deg.	Deg.	Deg.	In.	Deg.	Deg.	Deg.	In.	Deg.	In.	
1871	....	....	42·80	·40	....	....	59·60	1·80	..	..	66·80	2·40	..	..	76·60	2·30	....	....	76·40	14·10	....	....	74·60	3·80	65·81	24·30	10
1872	....	....	32·70	1·40	....	....	47·70	2·40	..	..	57·10	4·40	..	..	73·06	4·70	....	....	75·17	7·40	....	....	74·53	·90	55·57	20·70	10
1873	....	....	—4	36·37	·70	78	26	45·22	15·90	89	41	59·11	19·00	94	60	75·08	4·80	96	69	75·54	6·40	105	49	77·98	1·00	61·00	46·99	12
1874	60		7	32·15	2·51	88	12	44·65	4·09	92	88	67·48	3·15	94	44	74·31	18·02	113	55	82·35	1·10	111	53	78·71	1·40	63·32	30·37	7
1875	72		—3	29·11	3·38	84	20	44·81	4·62	96	25	71·00	3·98	95	43	71·20	13·58	97	57	74·13	6·72	86	51	69·68	8·40	63·71	40·68	28
1876	60		—4	27·92	2·09	83	30	51·12	5·16	88	35	63·73	3·10	94	44	68·63	4·58	95	54	75·71	7·44	92	51	74·18	8·39	60·33	30·76	8
1877	75		0	32·46	1·01	79	22	49·27	5·88	84	35	59·06	7·57	90	40	67·45	6·41	94	48	73·34	2·20	94	52	71·75	4·56	59·08	27·72	7
1878	81		19	46·74	3·09	83	31	53·95	4·01	81	32	57·49	5·54	86	44	66·39	9·64	94	55	76·91	11·61	95	52	76·27	1·23	60·33	35·12	4
1879	85		1	40·78	2·15	80	12	52·32	2·17	91	34	65·84	5·94	90	41	70·51	5·05	94	56	75·84	3·10	94	50	73·71	2·16	63·18	20·57	31
1880	83		—16	36·24	·56	93	28	52·26	·74	94	42	69·41	5·68	92	45	71·80	1·57	93	51	75·19	4·78	95	41	74·00	5·42	61·47	18·70	8
1881	58			1·26·3	1·31	81	4	43·70	4·09	85	39	67·03	6·57	96	50	73·32	3·99	98	54	76·45	3·68	102	58	78·90	1·42	61·03	21·04	3
1882	80		2	39·16	1·11	86	29	50·76	3·92	83	34	54·85	4·49	92	43	69·23	5·77	89	48	68·48	4·26	88*	48	70·77	1·26	56·18	20·81	24

* Only twenty days of August included.

the several seasons and the growth made during the same, I selected from my meteorological records the maximum, minimum, and mean temperature, and the rain-fall, of the six growing months of spring and summer of each of the twelve years of growth. These extracts I have tabulated, and have also appended to each season the thickness of the ring formed, as measured on the oblique cut previously described.

An examination of this table shows a general relation of cause and effect between high temperature and large rain-fall, and greater growth. But it falls very far short of proving a general law of "so much heat and so much water during the growing season, to produce so much wood." For example, compare the years 1875 and 1878. The temperature of 1878 for the season is better than 4° in excess of the season of 1875, and the rain-fall only a little over four inches less; and yet the growth of 1875 is *seven times* what it was in 1878. This almost unparalleled growth of 1875—that is, as compared with the other years—can not be explained by the above general law. But I think the May and June record of that year throws light upon it. We see there a maximum heat in May of 96° (higher than I have ever known it in an observation and record of twenty-five years), and a mean temperature of the whole month, also unequaled, of 71°; and this great heat continued through the month of June, and no cold spells after the heat set in sufficient to check the growth. Then, in connection with this heat, the ground was well saturated with water when this heated term began (May 6th) by 1·62 inch of rain on the 4th. From this on, to the 26th of June, 15 inches more of rain fell, so apportioned over the time as to keep the ground saturated. This synchronous excess of heat and water evidently produced the abnormal growth. And probably, as this matter is further studied, it will be found that these agents, rightly proportioned, operating synchronously, produce these thicker rings; while as one or the other is in excess, or absent, the growth is checked, and thus has time to condense and harden, and form these sub-rings; and the more frequent these alternations, the greater the number of them.

SCIENCE IN RELATION TO THE ARTS.

By C. WILLIAM SIEMENS, F. R. S.

II.

GAS is an institution of the utmost value to the artisan; it requires hardly any attention, is supplied upon regulated terms, and gives with what should be a cheerful light a genial warmth, which often saves the lighting of a fire. The time is, moreover, not far distant, I venture to think, when both rich and poor will largely resort to gas as

the most convenient, the cleanest, and the cheapest of heating agents, and when raw coal will be seen only at the colliery or the gas-works. In all cases where the town to be supplied is within say thirty miles of the colliery, the gas-works may with advantage be planted at the mouth, or still better at the bottom of the pit, whereby all haulage of fuel would be avoided, and the gas, in its ascent from the bottom of the colliery, would acquire an onward pressure sufficient probably to impel it to its destination. The possibility of transporting combustible gas through pipes for such a distance has been proved at Pittsburg, where natural gas from the oil district is used in large quantities.

The *quasi* monopoly so long enjoyed by gas companies has had the inevitable effect of checking progress. The gas being supplied by meter, it has been seemingly to the advantage of the companies to give merely the prescribed illuminating power, and to discourage the invention of economical burners, in order that the consumption might reach a maximum. The application of gas for heating purposes has not been encouraged, and is still made difficult, in consequence of the objectionable practice of reducing the pressure in the mains during day-time to the lowest possible point consistent with prevention of atmospheric indraught. The introduction of the electric light has convinced gas managers and directors that such a policy is no longer tenable, but must give way to one of technical progress ; new processes for cheapening the production and increasing the purity and illuminating power of gas are being fully discussed before the Gas Institute ; and improved burners, rivaling the electric light in brilliancy, greet our eyes as we pass along our principal thoroughfares.

Regarding the importance of the gas-supply as it exists at present, we find from a government return that the capital invested in gas-works in England, other than those of local authorities, amounts to £30,000,000 ; in these, 4,281,048 tons of coal are converted annually, producing 43,000,000,000 cubic feet of gas, and about 2,800,000 tons of coke ; whereas the total amount of coal annually converted in the United Kingdom may be estimated at 9,000,000 tons, and the by-products therefrom at 500,000 tons of tar, 1,000,000 tons of ammonia liquor, and 4,000,000 tons of coke, according to the returns kindly furnished me by the managers of many of the gas-works and corporations. To these may be added say 120,000 tons of sulphur, which up to the present time is a waste product.

Previous to the year 1856—that is to say, before Mr. W. H. Perkin had invented his practical process, based chiefly upon the theoretical investigations of Hoffman, regarding the coal-tar bases and the chemical constitution of indigo—the value of coal-tar in London was scarcely a halfpenny a gallon, and in country places gas-makers were glad to give it away. Up to that time the coal-tar industry had consisted

chiefly in separating the tar by distillation into naphtha, creosote, oils, and pitch. A few distillers, however, made small quantities of benzene, which had been first shown—by Mansfield, in 1849—to exist in coal-tar naphtha mixed with toluene, cumene, etc. The discovery, in 1856, of the mauve or aniline purple gave a great impetus to the coal-tar trade, inasmuch as it necessitated the separation of large quantities of benzene, or a mixture of benzene and toluene, from the naphtha. The trade was further increased by the discovery of the magenta or rosaniline dye, which required the same products for its preparation. In the mean time, carbolic acid was gradually introduced into commerce, chiefly as a disinfectant, but also for the production of coloring-matter.

The next most important development arose from the discovery by Graebe and Liebermann that alizarine, the coloring principle of the madder-root, was allied to anthracene, a hydrocarbon existing in coal-tar. The production of this coloring-matter from anthracene followed, and is now one of the most important operations connected with tar-distilling. The success of the alizarine made in this manner has been so great that it has almost entirely superseded the use of madder, which is now cultivated to only a comparatively small extent. The most important coloring-matters recently introduced are the azo-scarlets. They have called into use the coal-tar hydrocarbons, xylene and cumene. Naphthalene is also used in their preparation. These splendid dyes have replaced cochineal in many of its applications, and have thus seriously interfered with its use. The discovery of artificial indigo by Professor Baeyer is of great interest. For the preparation of this coloring-matter toluene is required. At present artificial indigo does not compete seriously with the natural product; but, should it eventually be prepared in quantity from toluene, a further stimulus will be given to the coal-tar trade.

The color industry utilizes even now practically all the benzene, a large proportion of the solvent naphtha, all the anthracene, and a portion of the naphthaline resulting from the distillation of coal-tar; and the value of the coloring-matter thus produced is estimated by Mr. Perkin at £3,350,000.

The demand for ammonia may be taken as unlimited, on account of its high agricultural value as a manure; and, considering the failing supply of guano and the growing necessity for stimulating the fertility of our soil, an increased production of ammonia may be regarded as a matter of national importance, for the supply of which we have to look almost exclusively to our gas-works. The present production of 1,000,000 tons of liquor yields 95,000 tons of sulphate of ammonia, which, taken at £20 10s. a ton, represents an annual value of £1,947,000.

The total annual value of the gas-works by-products may be estimated as follows:

Coloring-matter	£3,350,000
Sulphate of ammonia	1,947,000
Pitch (325,000 tons)	365,000
Creosote (25,000,000 gallons)	208,000
Crude carbolic acid (1,000,000 gallons)	100,000
Gas-coke, 4,000,000 tons (after allowing 2,000,000 tons consumption in working the retorts) at 12s.	2,400,000
Total	£8,370,000

Taking the coal used, 9,000,000 tons at 12s., equal £5,400,000, it follows that the by-products exceed in value the coal used by very nearly £3,000,000.

In using raw coal for heating purposes these valuable products are not only absolutely lost to us, but in their stead we are favored with those semi-gaseous by-products in the atmosphere too well known to the denizens of London and other large towns as smoke. Professor Roberts has calculated that the soot in the pall hanging over London on a winter's day amounts to fifty tons, and that the carbonic oxide, a poisonous compound, resulting from the imperfect combustion of coal, may be taken as at least five times that amount. Mr. Aitken has shown, moreover, in an interesting paper communicated to the Royal Society of Edinburgh, last year, that the fine dust resulting from the imperfect combustion of coal is mainly instrumental in the formation of fog; each particle of solid matter attracting to itself aqueous vapor; these globules of fog are rendered particularly tenacious and disagreeable by the presence of tar-vapor, another result of imperfect combustion of raw fuel, which might be turned to much better account at the dye-works. The hurtful influence of smoke upon public health, the great personal discomfort to which it gives rise, and the vast expense it indirectly causes through the destruction of our monuments, pictures, furniture, and apparel, are now being recognized, as is evinced by the success of recent Smoke Abatement Exhibitions. The most effectual remedy would result from a general recognition of the fact that, wherever smoke is produced, fuel is being consumed wastefully, and that all our calorific effects, from the largest down to the domestic fire, can be realized as completely and more economically, without allowing any of the fuel employed to reach the atmosphere unburnt. This most desirable result may be effected by the use of gas for all heating purposes, with or without the addition of coke or anthracite.

The cheapest form of gas is that obtained through the entire distillation of fuel in such gas-producers as are now largely used in working the furnaces of glass, iron, and steel works; but gas of this description would not be available for the supply of towns owing to its bulk, about two thirds of its volume being nitrogen. The use of water-gas, resulting from the decomposition of steam in passing through a hot chamber filled with coke, has been suggested, but this gas is also objectionable, because it contains, besides hydrogen, the poisonous and inodorous

gas, carbonic oxide, the introduction of which into dwelling-houses could not be effected without considerable danger. A more satisfactory mode of supplying heating separately from illuminating-gas would consist in connecting the retort at different periods of the distillation with two separate systems of mains for the delivery of the respective gases. Experiments made some years ago by Mr. Ellisen, of the Paris gas-works, have shown that the gases rich in carbon, such as olefiant and acetylene, are developed chiefly during an interval of time, beginning half an hour after the commencement and terminating at half the whole period of distillation, while during the remainder of the time, marsh gas and hydrogen are chiefly developed, which, while possessing little illuminating power, are most advantageous for heating purposes. By resorting to improved means of heating the retorts with gaseous fuel, such as have been in use at the Paris gas-works for a considerable number of years, the length of time for effecting each distillation may be shortened from six hours, the usual period in former years, to four, or even three hours, as now practiced at Glasgow and elsewhere. By this means a given number of retorts can be made to produce, in addition to the former quantity of illuminating-gas of superior quality, a similar quantity of heating-gas, resulting in a diminished cost of production and an increased supply of the valuable by-products previously referred to. The quantity of both ammonia and heating-gas may be further increased by the simple expedient of passing a streamlet of steam through the heated retorts toward the end of each operation, whereby the ammonia and hydrocarbons still occluded in the heated coke will be evolved, and the volume of heating-gas produced be augmented by the products of decomposition of the steam itself. It has been shown that gas may be used advantageously for domestic purposes with judicious management even under present conditions, and it is easy to conceive that its consumption for heating would soon increase, perhaps tenfold, if supplied separately at say one shilling a thousand cubic feet. At this price gas would be not only the cleanest and most convenient, but also the cheapest form of fuel, and the enormous increase of consumption, the superior quality of the illuminating-gas obtained by selection, and the proportionate increase of by-products, would amply compensate the gas company or corporation for the comparatively low price of the heating-gas.

The greater efficiency of gas as a fuel results chiefly from the circumstance that a pound of gas yields in combustion twenty-two thousand heat-units, or exactly double the heat produced in the combustion of a pound of ordinary coal. This extra heating power is due partly to the freedom of the gas from earthy constituents, but chiefly to the heat imparted to it in effecting its distillation. Recent experiments with gas-burners have shown that in this direction also there is much room for improvement.

The amount of light given out by a gas-flame depends upon the

temperature to which the particles of solid carbon in the flame are raised, and Dr. Tyndall has shown that, of the radiant energy set up in such a flame, only the $\frac{1}{25}$ part is luminous; the hot products of combustion carry off at least four times as much energy as is radiated, so that not more than one hundredth part of the heat evolved in combustion is converted into light. This proportion could be improved, however, by increasing the temperature of combustion, which may be effected either by intensified air-currents or by regenerative action. Supposing that the heat of the products of combustion could be communicated to metallic surfaces, and be transferred by conduction or otherwise to the atmospheric air supporting combustion in the flame, we should be able to increase the temperature accumulatively to any point within the limit of dissociation; this limit may be fixed at about 2,300° C., and can not be very much below that of the electric arc. At such a temperature the proportion of luminous rays to the total heat produced in combustion would be more than doubled, and the brilliancy of the light would at the same time be greatly increased. Thus improved, gas-lighting may continue its rivalry with electric lighting both as regards economy and brilliancy, and such rivalry must necessarily result in great public advantage.

In the domestic grate radiant energy of inferior intensity is required, and I for one do not agree with those who would like to see the open fire-place of this country superseded by the Continental stove. The advantages usually claimed for the open fire-place are, that it is cheerful, "pokable," and conducive to ventilation; but to these may be added another of even greater importance, viz., that the radiant heat which it emits passes through the transparent air without warming it, and imparts heat only to the solid walls, floor, and furniture of the room, which are thus constituted the heating surfaces of the comparatively cool air of the apartments in contact with them. In the case of stoves, the heated air of the room causes deposit of moisture upon the walls in heating them, and gives rise to mildew and germs injurious to health. It is, I think, owing to this circumstance that upon entering an apartment one can immediately perceive whether or not it is heated by an open fire-place; nor is the unpleasant sensation due to stove-heating completely removed by mechanical ventilation; there is, moreover, no good reason why an open fire-place should not be made as economical and smokeless as a stove or hot-water apparatus.

In the production of mechanical effect from heat, gaseous fuel also presents most striking advantages, as will appear from the following consideration. When we have to deal with the question of converting mechanical into electrical effect, or *vice versa*, by means of the dynamo-electrical machine, we have only to consider what are the equivalent values of the two forms of energy, and what precautions are necessary to avoid losses by the electrical resistance of conductors and by fric-

tion. The transformation of mechanical effect into heat involves no losses except those resulting from imperfect installation, and these may be so completely avoided that Dr. Joule was able by this method to determine the equivalent values of the two forms of energy. But, in attempting the inverse operation of effecting the conversion of heat into mechanical energy, we find ourselves confronted by the second law of thermo-dynamics, which says that, whenever a given amount of heat is converted into mechanical effect, another but variable amount descends from a higher to a lower potential, and is thus rendered unavailable.

In the condensing steam-engine this waste heat comprises that communicated to the condensing-water, while the useful heat, or that converted into mechanical effect, depends upon the difference of temperature between the boiler and condenser. The boiler-pressure is limited, however, by considerations of safety and convenience of construction, and the range of working temperature rarely exceeds 120° C., except in the engines constructed by Mr. Perkins, in which a range of 160° C., or an expansive action commencing at fourteen atmospheres, has been adopted with considerable promise of success, as appears from an able report on this engine by Sir Frederick Bramwell. To obtain more advantageous primary conditions we have to turn to the caloric or gas-engine, because in them the co-efficient of efficiency, expressed by $\frac{T-T'}{T}$, may be greatly increased. This value would reach a maximum if the initial absolute temperature T could be raised to that of combustion, and T′ reduced to atmospheric temperature, and these maximum limits can be much more nearly approached in the gas-engine worked by a combustible mixture of air and hydrocarbons than in the steam-engine.

Assuming, then, in an explosive gas-engine a temperature of 1,500° C., at a pressure of four atmospheres, we should, in accordance with the second law of thermo-dynamics, find a temperature after expansion to atmospheric pressure of 600° C., and therefore a working range of $1500° - 600° = 900°$, and a theoretical efficiency of $\frac{900}{1{,}500 + 274}$ = about one half, contrasting very favorably with that of a good expansive condensing steam-engine, in which the range is $150 - 30 = 120°$ C., and the efficiency $\frac{120}{150 + 274} = \frac{2}{7}$. A good expansive steam-engine is therefore capable of yielding as mechanical work two-seventh part of the heat communicated to the boiler, which does not include the heat lost by imperfect combustion, and that carried away in the chimney. Adding to these the losses by friction and radiation in the engine, we find that the best steam-engine yet constructed does not yield in mechanical effect more than one seventh part of the heat-energy residing in the fuel consumed. In the gas-engine we have also to make reductions from the theoretical efficiency, on account of the rather serious loss of heat by absorption into the

working cylinder, which has to be cooled artificially in order to keep its temperature down to a point at which lubrication is possible; this, together with frictional loss, can not be taken at less than one half, and reduces the factor of efficiency of the engine to one fourth.

It follows from these considerations that the gas or caloric engine combines the conditions most favorable to the attainment of maximum results, and it may reasonably be supposed that the difficulties still in the way of their application on a large scale will gradually be removed. Before many years have elapsed we shall find in our factories and on board our ships engines with a fuel-consumption not exceeding one pound of coal per effective horse-power per hour, in which the gas-producer takes the place of the somewhat complex and dangerous steam-boiler. The advent of such an engine and of the dynamo-machine must mark a new era of material progress at least equal to that produced by the introduction of steam-power in the early part of our century. Let us consider what would be the probable effect of such an engine upon that most important interest of this country—the merchant navy.

According to returns kindly furnished me by the Board of Trade and "Lloyd's Register of Shipping," the total value of the merchant shipping of the United Kingdom may be estimated at £126,000,000, of which £90,000,000 represent steamers having a net tonnage of 3,003,988 tons; and £36,000,000 sailing-vessels, of 3,688,008 tons. The safety of this vast amount of shipping, carrying about five sevenths of our total imports and exports, or £500,000,000 of goods in the year, and of the more precious lives connected with it, is a question of paramount importance. It involves considerations of the most varied kind: comprising the construction of the vessel itself, and the material employed in building it; its furniture of engines, pumps, sails, tackle, compass, sextant, and sounding apparatus, the preparation of reliable charts for the guidance of the navigator, and the construction of harbors of refuge, light-houses, beacons, bells, and buoys, for channel navigation. Yet notwithstanding the combined efforts of science, inventive skill, and practical experience—the accumulation of centuries—we are startled with statements to the effect that during last year as many as 1,007 British-owned ships were lost, of which fully two thirds were wrecked upon our shores, representing a total value of nearly £10,000,000. Of these ships 870 were sailing-vessels and 137 steamers, the loss of the latter being in a fourth of the cases attributable to collision. The number of sailing-vessels included in these returns being 19,325, and of steamers 5,505, it appears that the steamer is the safer vessel, in the proportion of 4·43 to 3·46; but the steamer makes on an average three voyages for one of the sailing-ship taken over the year, which reduces the relative risk of the steamer as compared with the sailing-ship per voyage in the proportion of 13·29 to 3·46. Commercially speaking, this factor of safety in favor of steam-shipping is to a

great extent counterbalanced by the value of the steamship, which bears to that of the sailing-vessel per net carrying ton the proportion of 3 : 1, thus reducing the ratio in favor of steam-shipping as 13·29 to 10·38, or in round numbers as as 4 : 3. In testing this result by the charges of premium for insurance, the variable circumstances of distance, nature of cargo, season, and voyage have to be taken into account; but, judging from information received from ship-owners and underwriters of undoubted authority, I find that the relative insurance paid for the two classes of vessel represents an advantage of 30 per cent in favor of steam-shipping, agreeing very closely with the above deductions derived from statistical information.

In considering the question how the advantages thus established in favor of steam-shipping could be further improved, attention should be called in the first place to the material employed in their construction. A new material was introduced for this purpose by the Admiralty in 1876–'78, when they constructed at Pembroke dock-yard the two steam corvettes, the Iris and Mercury, of mild steel. The peculiar qualities of this material are such as have enabled ship-builders to save 20 per cent in the weight of the ship's hull, and to increase to that extent its carrying capacity. It combines, with a strength of thirty per cent superior to that of iron, such extreme toughness, that in the case of collision the side of the vessel has been found to yield or bulge several feet without showing any signs of rupture, a quality affecting the question of sea-risk very favorably. When to the use of this material there are added the advantages derived from a double bottom, and from the division of the ship's hold by means of bulk-heads of solid construction, it is difficult to conceive how such a vessel could perish by collision either with another vessel or with a sunken rock. The spaces between the two bottoms are not lost, because they form convenient chambers for water-ballast, but powerful pumps should in all cases be added to meet emergencies.

The following statement of the number and tonnage of vessels building and preparing to be built in the United Kingdom on the 30th of June last, which has been kindly furnished me by Lloyd's, is of interest as showing that wooden ships are fast becoming obsolete, and that even iron is beginning to yield its place, both as regards steamers and sailing-ships, to the new material mild steel; it also shows that by far the greater number of vessels now building are ships of large dimensions propelled by engine-power:

	MILD STEEL.		IRON.		WOOD.		TOTAL.	
	No.	Tons gross.	No.	Tons gross.	No.	Tons gross.	No.	Tons gross.
Steam.....	89	159,751	555	929,921	6	460	650	1,090,132
Sailing.....	11	16,800	70	120,259	49	4,635	130	141,694
	100	176,551	625	1,050,180	55	5,095	780	1,232,826

If to the improvements already achieved could be added an engine of half the weight of the present steam-engine and boilers, and working with only half the present expenditure of fuel, a further addition of 30 per cent could be made to the cargo of an Atlantic propeller vessel—no longer to be called a steamer—and the balance of advantages in favor of such vessels would be sufficient to restrict the use of sailing-craft chiefly to the regattas of this and neighboring ports.

The admirable work on the "British Navy," lately published by Sir Thomas Brassey, the Civil Chief Lord of the Admiralty, shows that the naval department of this country is fully alive to all improvements having regard to the safety as well as to the fighting qualities of her Majesty's ships of war, and recent experience goes far to prove that, although high speed and manœuvring qualities are of the utmost value, the armor-plate which appeared to be fast sinking in public favor is not without its value in actual warfare.

The progressive views perceptible in the construction of the navy are further evidenced in a remarkable degree in the hydrographic department. Captain Sir Frederick Evans, the hydrographer, and Vice-President of the British Association, gave us at York last year a very interesting account of the progress made in that department, which, while dealing chiefly with the preparation of charts showing the depth of water, the direction and force of currents, and the rise of tides near our shores, contains also valuable statistical information regarding the more general questions of the physical conditions of the sea, its temperature at various depths, its flora and fauna, as also the rain-fall, and the nature and force of prevailing winds. In connection with this subject the American Naval Department has taken an important part, under the guidance of Captain Maury and the Agassiz father and son, while in this country the persistent labors of Dr. William Carpenter deserve the highest consideration.

Our knowledge of tidal action has received a most powerful impulse through the invention of a self-recording gauge and tide-predicter, which will form the subject of one of the discourses to be delivered at our present meeting by its principal originator, Sir William Thomson; when I hope he will furnish us with an explanation of some extraordinary irregularities in tidal records, observed some years ago by Sir John Coode at Portland, and due apparently to atmospheric influence.

The application of iron and steel in naval construction rendered the use of the compass for some time illusory, but in 1839 Sir George Airy showed how the errors of the compass, due to the influence experienced from the iron of the ship, may be perfectly corrected by magnets and soft iron placed in the neighborhood of the binnacle, but the great size of the needles in the ordinary compasses rendered the correction of the quadrantal errors practically unattainable. In 1876 Sir William Thom-

son invented a compass with much smaller needles than those previously used, which allows Sir George Airy's principles to be applied completely. With this compass correctors can be arranged so that the needle shall point accurately in all directions, and these correctors can be adjusted at sea from time to time, so as to eliminate any error which may arise through change in the ship's magnetism, or in the magnetism induced by the earth through change of the ship's position. By giving the compass-card a long period of free oscillation, great steadiness is obtained when the ship is rolling.

Sir William Thomson has also enriched the art of navigation by the invention of two sounding-machines; the one being devised for ascertaining great depths very accurately in less than one quarter the time formerly necessary, and the other for taking depths up to 130 fathoms without stopping the ship in its onward course. In both these instruments steel piano-forte wire is used instead of the hempen and silken lines formerly employed; in the latter machine the record of depth is obtained not by the quantity of wire run over its counter and brake-wheel, but through the indications produced upon a simple pressure-gauge consisting of an inverted glass tube, whose internal surface is covered beforehand with a preparation of chromate of silver, rendered colorless by the sea-water up to the height to which it penetrates. The value of this instrument for guiding the navigator within what he calls "soundings" can hardly be exaggerated; with the sounding-machine and a good chart he can generally make out his position correctly by a succession of three or four casts in a given direction at given intervals, and thus in foggy weather is made independent of astronomical observations, and of the sight of light-houses or the shore. By the proper use of this apparatus, such accidents as happened to the mail-steamer Mosel not a fortnight ago would not be possible. As regards the value of the deep-sea instrument I can speak from personal experience, as on one occasion it enabled those in charge of the cable steamship Faraday to find the end of an Atlantic cable, which had parted in a gale of wind, with no other indication of the locality than a single sounding, giving a depth of 950 fathoms. To recover the cable a number of soundings in the supposed neighborhead of the broken end were taken, the 950 fathom contour line was then traced upon a chart, and the vessel thereupon trailed its grapnel two miles to the eastward of this line, when it soon engaged the cable twenty miles away from the point, where dead reckoning had placed the ruptured end.

Whether or not it will ever be practicable to determine oceanic depths without a sounding-line, by means of an instrument based upon gravimetric differences, remains to be seen. Hitherto the indications obtained by such an instrument have been encouraging, but its delicacy has been such as to unfit it for ordinary use on board a ship when rolling.

The time allowed me for addressing you on this occasion is wholly insufficient to do justice to the great engineering works of the present day, and I must therefore limit myself to making a short allusion to a few only of the more remarkable enterprises.

The great success, both technically and commercially, of the Suez Canal, has stimulated M. de Lesseps to undertake a similar work of even more gigantic proportions, namely, the piercing of the Isthmus of Panama by a ship-canal, forty miles long, fifty yards wide on the surface, and twenty yards at the bottom, upon a dead level from sea to sea. The estimated cost of this work is £20,000,000, and, more than this sum having been subscribed, it appears unlikely that political or climatic difficulties will stop M. de Lesseps in its speedy accomplishment. Through it, China, Japan, and the whole of the Pacific Ocean will be brought to half their present distance, as measured by the length of voyage, and an impulse to navigation and to progress will thus be given which it will be difficult to overestimate.

Side by side with this gigantic work, Captain Eads, the successful improver of the Mississippi navigation, intends to erect his ship railway, to take the largest vessels, fully laden and equipped, from sea to sea, over a gigantic railway across the Isthmus of Tehuantepec, a distance of ninety-five miles. Mr. Barnaby, the chief constructor of the navy, and Mr. John Fowler have expressed a favorable opinion regarding this enterprise, and it is to be hoped that both the canal and the ship-railway will be accomplished, as it may be safely anticipated that the traffic will be amply sufficient to support both these undertakings.

Whether or not M. de Lesseps will be successful also in carrying into effect the third great enterprise with which his name has been prominently connected, the flooding of the Tunis-Algerian Chotts, thereby re-establishing the Lake Tritonis of the ancients, with its verdure-clad shores, is a question which could only be decided upon the evidence of accurate surveys, but the beneficial influence of a large sheet of water within the African desert could hardly be matter of doubt.

It is with a feeling not unmixed with regret that I have to record the completion of a new Eddystone Light-house in substitution for the *chef-d'œuvre* of engineering erected by John Smeaton more than one hundred years ago. The condemnation of that structure was not, however, the consequence of any fault of construction, but was caused by inroads of the sea upon the rock supporting it. The new light-house, designed and executed by Mr. (now Sir James) Douglass, engineer of Trinity House, has been erected in the incredibly short time of less than two years, and bids fair to be worthy of its famed predecessor. Its height above high water is one hundred and thirty feet, as compared with seventy-two feet, the height of Telford's structure, which gives its powerful light a considerably increased range. The

system originally suggested by Sir William Thomson some years ago, of distinguishing one light from another by flashes following at varied intervals, has been adopted by the Elder Brethren in this as in other recent lights in the modified form introduced by Dr. John Hopkinson, in which the principle is applied to revolving lights, so as to obtain a greater amount of light in the flash.

The geological difficulties which for some time threatened the accomplishment of the St. Gothard Tunnel have been happily overcome, and this second and most important sub-Alpine thoroughfare now connects the Italian railway system with that of Switzerland and the south of Germany, whereby Genoa will be constituted the shipping port for those parts.

Whether we shall be able to connect the English with the French railway system by means of a tunnel below the English Channel is a question that appears dependent at this moment rather upon military and political than technical and financial considerations. The occurrence of a stratum of impervious gray chalk, at a convenient depth below the bed of the Channel, minimizes the engineering difficulties in the way, and must influence the financial question involved. The protest lately raised against its accomplishment can hardly be looked upon as a public verdict, but seems to be the result of a natural desire to pause pending the institution of careful inquiries. These inquiries have been made by a Royal Scientific Commission, and will be referred for further consideration to a mixed Parliamentary Committee, upon whose report it must depend whether the natural spirit of commercial enterprise has to yield in this instance to political and military considerations. Whether the Channel Tunnel is constructed or not, the plan proposed some years ago by Mr. John Fowler, of connecting England and France by means of a ferry-boat capable of taking railway trains, would be a desideratum justified by the ever-increasing intercommunication between this and Continental countries.

The public inconvenience arising through the obstruction to traffic by a sheet of water is well illustrated by the circumstance that both the estuaries of the Severn and of the Mersey are being undermined in order to connect the railway systems on the two sides, and that the Frith of Forth is about to be spanned by a bridge exceeding in grandeur anything as yet attempted by the engineer. The roadway of this bridge will stand one hundred and fifty feet above high-water mark, and its two principal spans will measure a third of a statute mile each. Messrs. Fowler and Baker, the engineers to whom this great work has been intrusted, could hardly have accomplished their task without having recourse to steel for their material of construction, nor need the steel used be of the extra-mild quality particularly applicable for naval structures to withstand collision, for, when such extreme toughness is not required, steel of very homogeneous quality can be produced, bearing a tensile strain double that of iron.

The tensile strength of steel, as is well known, is the result of an admixture of carbon with the iron, varying between one tenth and two per cent, and the nature of this combination of carbon with iron is a matter of great interest both from a theoretical and practical point of view. It could not be a chemical compound which would necessitate a definite proportion, nor could a mere dissolution of the one in the other exercise such remarkable influence upon the strength and hardness of the resulting metal. A recent investigation by Mr. Abel has thrown considerable light upon this question. A definite carbide of iron is formed, it appears, soluble at high temperatures in iron, but separating upon cooling the steel gradually, and influencing only to a moderate degree the physical properties of the metal as a whole. In cooling rapidly there is no time for the carbide to separate from the iron, and the metal is thus rendered both hard and brittle. Cooling the metal gradually, under the influence of great compressive force, appears to have a similar effect to rapid cooling in preventing the separation of the carbide from the metal, with this difference, that the effect is more equal throughout the mass, and that more uniform temper is likely to result.

When the British Association met at Southampton on a former occasion, Schönbein announced to the world his discovery of gun-cotton. This discovery has led the way to many valuable researches on explosives generally, in which Mr. Abel has taken a leading part. Recent investigations by him, in connection with Captain Noble, upon the explosive action of gun-cotton and gunpowder confined in a strong chamber, which have not yet been published, deserve particular attention. They show that while by the method of investigation pursued about twenty years ago by Karolye (of exploding gunpowder in very small charges in shells confined within a large shell partially exhausted of air) the composition of the gaseous products was found to be complicated and liable to variation, the chemical metamorphosis which gun-cotton sustains, when exploded under conditions such as obtain in its practical application, is simple and very uniform. Among other interesting points noticed in this direction was the fact that, as in the case of gunpowder, the proportion of carbonic acid increases, while that of carbonic oxide diminshes with the density of the charge. The explosion of gun-cotton, whether in the form of wool or loosely spun thread, or in the packed compressed form devised by Abel, furnished practically the same results if fired under pressure, that is, under strong confinement—the conditions being favorable to the full development of its explosive force; but some marked differences in the composition of the products of metamorphosis were observed when gun-cotton was fired by detonation. With regard to the tension exerted by the products of explosion, some interesting points were observed, which introduce very considerable difficulties into the investigation of the action of fired gun-cotton. Thus, whereas no marked

differences are observed in the tension developed by small charges and by very much larger charges of gunpowder having the same density (i. e., occupying the same volume relatively to the entire space in which they are exploded), the reverse is the case with respect to gun-cotton. Under similar conditions in regard to density of charge, 100 grammes of gun-cotton gave a measured tension of about 20 tons on the square inch, 1,500 grammes gave a tension of about 29 tons (in several very concordant observations), while a charge of 2·5 kilos gave a pressure of about 45 tons, this being the maximum measured tension obtained with a charge of gunpowder of five times the density of the above.

The extreme violence of the explosion of gun-cotton as compared with gunpowder when fired in a closed space was a feature attended with formidable difficulties. In whatever way the charge was arranged in the firing-cylinder, if it had free access to the inclosed crusher-gauge, the pressures recorded by the latter were always much greater than when means were taken to prevent the wave of matter suddenly set in motion from acting directly upon the gauge. The abnormal or wave-pressures recorded at the same time that the general tension in the cylinder was measured amounted in the experiment to 42·3 tons, when the general tension was recorded at 20 tons; and in another, when the pressure was measured at 29 tons, the wave-pressure recorded was 44 tons. Measurements of the temperature of explosion of gun-cotton showed it to be about double that of the explosion of gunpowder. One of the effects observed to be produced by this sudden enormous development of heat was the covering of the inner surfaces of the steel explosion-vessel with a net-work of cracks, small portions of the surface being sometimes actually fractured. The explosion of charges of gun-cotton up to 2·5 kilos in perfectly closed chambers, with development of pressures approaching to 50 tons on the square inch, constitutes alone a perfectly novel feat in investigations of this class.

Messrs. Noble and Abel are also continuing their researches upon fired gunpowder, being at present occupied with an inquiry into the influence exerted upon the chemical metamorphosis and ballistic effects of fired gunpowder by variation in its composition, their attention being directed especially to the discovery of the cause of the more or less considerable erosion of the interior surface of guns produced by the exploding charge—an effect which, notwithstanding the application of devices in the building up of the charge specially directed to the preservation of the gun's bore, has become so serious that, with the enormous charges now used in our heavy guns, the erosive action on the surface of the bore produced by a single round is distinctly perceptible. As there appeared to be *prima facie* reasons why the erosive action of powder upon the surface of the bore at the high temperatures developed should be at any rate in part due to its one component sulphur, Noble and Abel have made comparative experiments

with powders of usual composition and with others in which the proportion of sulphur was considerably increased, the extent of erosive action of the products escaping from the explosion-vessel under high tension being carefully determined. With small charges a particular powder containing no sulphur was found to exert very little erosive action as compared with ordinary cannon-powder; but another powder, containing the maximum proportion of sulphur tried (15 per cent), was found equal to it under these conditions, and exerted very decidedly less erosive action than it, when larger charges were reached. Other important contributions to our knowledge of the action of fired gunpowder in guns, as well as decided improvements in the gunpowder manufactured for the very heavy ordnance of the present day, may be expected to result from a continuance of these investigations. Professor Carl Himly, of Kiel, having been engaged upon investigations of a similar nature, has lately proposed a gunpowder in which hydrocarbons precipitated from solution in naphtha take the place of the charcoal and sulphur of ordinary powder. This powder has among others the peculiar property of completely resisting the action of water, so that the old caution, "Keep your powder dry," may hereafter be unnecessary.

The extraordinary difference of condition, before and after its ignition, of such matter as constitutes an explosive agent leads us up to a consideration of the aggregate state of matter under other circumstances. As early as 1776, Alexander Volta observed that the volume of glass was changed under the influence of electrification, by what he termed electrical pressure. Dr. Kerr, Govi, and others have followed up the same inquiry, which is at present continued chiefly by Dr. George Quincke, of Heidelberg, who finds that temperature, as well as chemical constitution of the dielectric under examination, exercises a determining influence upon the amount and character of the change of volume effected by electrification; that the change of volume may under certain circumstances be effected instantaneously as in flint-glass, or only slowly as in crown-glass, and that the elastic limit of both is diminished by electrification, whereas in the case of mica and of gutta-percha an increase of elasticity takes place.

Still greater strides are being made at the present time toward a clearer perception of the condition of matter when particles are left some liberty to obey individually the forces brought to bear upon them. By the discharge of high-tension electricity through tubes containing highly rarefied gases (Geissler's tubes), phenomena of discharge were produced which were at once most striking and suggestive. The Sprengel pump afforded a means of pushing the exhaustion to limits which had formerly been scarcely reached by the imagination. At each step the condition of attenuated matter revealed varying properties when acted upon by electrical discharge and magnetic force.

The radiometer of Crookes imported a new feature into these inquiries, which at the present time occupy the attention of leading physicists in all countries.

The means usually employed to produce electrical discharge in vacuum-tubes was Ruhmkorff's coil; but Mr. Gassiot first succeeded in obtaining the phenomena by means of a galvanic battery of 3,000 Leclanché cells. Dr. De La Rue, in conjunction with his friend Dr. Hugo Müller, has gone far beyond his predecessors in the production of batteries of high potential. At his lecture "On the Phenomena of Electric Discharge," delivered at the Royal Institution, in January, 1881, he employed a battery of his invention consisting of 14,400 cells (14,832 Volts), which gave a current of 0·054 Ampère, and produced a discharge at a distance of 0·71 inch between the terminals. During last year, he increased the number of cells to 15,000 (15,450 Volts), and increased the current to 0·4 Ampère, or eight times that of the battery he used at the Royal Institution.

With the enormous potential and perfectly steady current at his disposal, Mr. De La Rue has been able to contribute many interesting facts to the science of electricity. He has shown, for example, that the beautiful phenomena of the stratified discharge in exhausted tubes are but a modification and a magnification of those of the electric arc at ordinary atmospheric pressure. Photography was used in his experiments to record the appearance of the discharge, so as to give a degree of precision otherwise unattainable in the comparison of the phenomena. He has shown that between two points the length of the spark, provided the insulation of the battery is efficacious, is as the square of the number of cells employed. Mr. De La Rue's experiments have proved that at all pressures the discharge in gases is not a current in the ordinary acceptation of the term, but is of the nature of a disruptive discharge. Even in an apparently perfectly steady discharge in a vacuum-tube, when the strata as seen in a rapidly revolving mirror are immovable, he has shown that the discharge is a pulsating one; but, of course, the period must be of a very high order.

At the Royal Institution, on the occasion of his lecture, Mr. De La Rue produced, in a very large vacuum-tube, an imitation of the aurora borealis; and he has deduced from his experiments that the greatest brilliancy of aurora displays must be at an altitude of from thirty-seven to thirty-eight miles—a conclusion of the highest interest, and in opposition to the extravagant estimate of 281 miles at which it had been previously put.

The President of the Royal Society has made the phenomena of electrical discharge his study for several years, and resorted in his important experiments to a special source of electric power. In a note addressed to me, Dr. Spottiswoode describes the nature of his investigations much more clearly than I could venture to give them. He says: "It had long been my opinion that the dissymmetry shown in

electrical discharges through rarefied gases must be an essential element of every disruptive discharge, and that the phenomena of stratification might be regarded as magnified images of features always present, but concealed under ordinary circumstances. It was with a view to the study of this question that the researches by Moulton and myself were undertaken. The method chiefly used consisted in introducing into the circuit intermittence of a particular kind, whereby one luminous discharge was rendered sensitive to the approach of a conductor outside the tube. The application of this method enabled us to produce artificially a variety of phenomena, including that of stratification. We were thus led to a series of conclusions relating to the mechanism of the discharge, among which the following may be mentioned:

"1. That a stria, with its attendant dark space, forms a physical unit of a striated discharge; that a striated column is an aggregate of such units formed by means of a step-by-step process; and that the negative glow is merely a localized stria, modified by local circumstances.

"2. That the origin of the luminous column is to be sought for at its negative end; that the luminosity is an expression of a demand for negative electricity; and that the dark spaces are those regions where the negative terminal, whether metallic or gaseous, is capable of exerting sufficient influence to prevent such demand.

"3. That the time occupied by electricity of either name in traversing a tube is greater than that occupied in traversing an equal length of wire, but less than that occupied by molecular streams (Crookes's radiations) in traversing the tubes. Also that, especially in high vacua, the discharge from the negative terminal exhibits a durational character not found at the positive.

"4. That the brilliancy of the light with so little heat may be due in part to brevity in the duration of the discharge; and that, for action so rapid as that of individual discharges, the mobility of the medium may count as nothing; and that for these infinitesimal periods of time gas may itself be as rigid and as brittle as glass.

"5. That striæ are not merely loci in which electrical is converted into luminous energy, but are actual aggregations of matter.

"This last conclusion was based mainly upon experiments made with an induction-coil excited in a new way—viz., directly by an alternating machine, without the intervention of a commutator or condenser. This mode of excitement promises to be one of great importance in spectroscopic work, as well as in the study of the discharge in a magnetic field, partly on account of the simplification which it permits in the construction of induction-coils, but mainly on account of the very great increase of strength in the secondary currents to which it gives rise."

These investigations assume additional importance when we view

them in connection with solar—I may even say stellar—physics, for evidence is augmenting in favor of the view that interstellar space is not empty, but is filled with highly attenuated matter of a nature such as may be put into our vacuum-tubes. Nor can the matter occupying stellar space be said any longer to be beyond our reach for chemical and physical test. The spectroscope has already thrown a flood of light upon the chemical constitution and physical condition of the sun, the stars, the comets, and the far-distant nebulæ, which have yielded spectroscopic photographs under the skillful management of Dr. Huggins, and Dr. Draper, of New York. Armed with greatly improved apparatus, the physical astronomer has been able to reap a rich harvest of scientific information during the short periods of the last two solar eclipses; that of 1879, visible in America, and that of May last, observed in Egypt by Lockyer, Schuster, and by Continental observers of high standing. The result of this last eclipse expedition has been summed up as follows: "Different temperature levels have been discovered in the solar atmosphere; the constitution of the corona has now the possibility of being determined, and it is proved to shine with its own light. A suspicion has been aroused once more as to the existence of a lunar atmosphere, and the position of an important line has been discovered. Hydrocarbons do not exist close to the sun, but may in space between us and it."

To me personally these reported results possess peculiar interest, for in March last I ventured to bring before the Royal Society a speculation regarding the conservation of solar energy, which was based upon the three following postulates, viz.:

1. That aqueous vapor and carbon compounds are present in stellar or interplanetary space.

2. That these gaseous compounds are capable of being dissociated by radiant solar energy while in a state of extreme attenuation.

3. That the effect of solar rotation is to draw in dissociated vapors upon the polar surfaces, and to eject them, after combustion has taken place, back into space equatorially.

It is therefore a matter of peculiar gratification to me that the results of observation here recorded give considerable support to that speculation. The luminous equatorial extensions of the sun which the American observations revealed in such a striking manner (with which I was not acquainted when writing my paper) were absent in Egypt; but the outflowing equatorial streams I suppose to exist could only be rendered visible by reflected sunlight, when mixed with dust produced by exceptional solar disturbances or by electric discharge; and the occasional appearance of such luminous extensions would serve only to disprove the hypothesis entertained by some, that they are divided planetary matter, in which case their appearance should be permanent. Professor Langley, of Pittsburg, has shown, by means of his bolometer, that the solar actinic rays are absorbed chiefly in the solar instead of

in the terrestrial atmosphere, and Captain Abney has found by his new photometric method that absorption due to hydrocarbons takes place somewhere between the solar and terrestrial atmosphere; in order to test this interesting result still further, he has lately taken his apparatus to the top of the Riffel with a view of diminishing the amount of terrestrial atmospheric air between it and the sun, and intends to bring a paper on this subject before Section A. Stellar space filled with such matter as hydrocarbon and aqueous vapor would establish a material continuity between the sun and his planets, and between the innumerable solar systems of which the universe is composed. If chemical action and reaction can further be admitted, we may be able to trace certain conditions of thermal dependence and maintenance, in which we may recognize principles of high perfection, applicable also to comparatively humble purposes of human life.

We shall thus find that, in the great workshop of Nature, there are no lines of demarkation to be drawn between the most exalted speculation and commonplace practice, and that all knowledge must lead up to one great result, that of an intelligent recognition of the Creator through his works. So, then, we members of the British Association and fellow-workers in every branch of science may exhort one another in the words of the American bard who has so lately departed from among us:

"Let us then be up and doing,
With a heart for any fate;
Still achieving, still pursuing,
Learn to labor and to wait."

MUSICAL SENSATIONS.

By M. HÉRICOURT.

IT is common, in defining music, to compare it with some other art, painting, for instance, and say it is to the ear what that is to the eye; that it is the representation of the ideal by a means especially adapted to the organ to which it is addressed, or by the combination of sounds. Is that all that it is? Do we not forget, when we simply put it on a par with other arts, the exceptional part it plays in the life of men? The universal adaptation of music to all degrees of civilization, the peculiar charm of which it is the source, and the extraordinary power it exercises, are so many reasons for believing that it is connected with our organization by a more intimate tie than that which binds other arts to it, and that it is the manifestation of a more general faculty. When Fetis wrote, in 1837, the idea prevailed that music originated in the imitation of the songs of birds. He

contradicted this, and defined music as the double result of the conformation of the organs and the disposition of the soul, as the art of awakening emotion by means of the combination of sounds. It is, in fact, generally agreed that music addresses itself more directly to our feelings and passions, and is correctly said that it speaks to them in a special language. Descartes indicated this as its object.

In the theory of Helmholtz, music expresses the different dispositions of the soul by imitating the characteristic particularities of movement in space, and by thus translating the forces and impulses that produce the movement. While he admits that it may have been at first only an imitation of the instinctive modulations of the voice corresponding with the different states of the mind, he does not consider this fact contradictory to his definition, for the natural processes of vocal expression are capable of being traced back to the same elements. "Rhythm and accentuation express directly the rapidity and vivacity of corresponding psychical movements; a vehement effort causes the voice to rise; the desire to produce an agreeable impression on another person prompts us to select a pleasant tone; and thus the efforts to imitate the involuntary modulations of the voice, to enrich and make more expressive the recitation of words, may very probably have guided our ancestors in seeking out the means for musical expression."

This is probably the real origin of music; and it is in this direction that we should look in investigating its nature.

Two elements closely connected, but quite different and having each its peculiar function, may be distinguished in the analysis of spoken language—the intonation and the articulation of the emitted sound. No doubt they are the interpreters of the two great human faculties of intelligence and feeling. Speech, then, is a complex physiological resultant, the double image of a double inner condition. The elements it represents can not be conceived as isolated from each other, any more than we can conceive a human organization a pure intelligence. We all know the important part intonation plays in conversation, and how by it the general sense, the whole expression of the spoken words, may be varied indefinitely.

Having thus found the origin of music in the imitation of these instinctive modulations of speech, it should be easy to draw from this an exact idea of its nature; for, without doubt, to read verse well, to declaim with warmth and conviction, is only to perform in advance the work of the musician. We have now a whole class of musical phrases which are only exaggerations of spoken intonations; they are our recitatives. The music of uncultivated peoples is mostly recitative; so also was a large part of the music of the middle ages. The rules and grammar of music and its particular features are the growth of modern times.

This conception of music as the language of sensibility permits us

to explain the characteristic features of its action. We must consider, first, that this language, like its twin sister the language of ideas, has suffered a progressive evolution, and has with us reached a great perfection, and consequently a great complexity in its laws and processes. Among primitive peoples of few ideas, whose feelings show few variations of shade in expression, music is almost wholly confined to a few modulations expressive of the principal divisions of feeling—love, joy, sorrow, and warlike ardor. Civilization, with its refinements, has produced a music that has grown constantly richer in shades and means of expression, to the point which has been reached by the great masters of our age.

Neither language is intelligible to all, in its fullest degree of development. As we must have the power of comprehending abstract ideas in order to understand philosophers, so we must be more or less accustomed to musical sensations to appreciate the great musicians; and it is interesting to observe how we learn by study to enjoy works which at first fall cold upon us.

The application of such a word as comprehend, or understand, to music, is a source of numerous misconceptions; music does not understand, it feels. It addresses itself only to that part of us which is susceptible of emotion; and we frequently lose all its charm by our trying to understand it, or to find in it ideas which it can not express. We might expect the same kind of a failure if we should try to find sources of emotion in the working out of an equation.

It is true that persons exist who have no sense for music, and to whom its language is a blank; but they are rarely found, and prove nothing. Opposed to them are much more frequent instances of excessively sensitive natures, on whom even simple single musical intervals produce wonderful effects. Who has not made music without suspecting it? In certain states of feeling we are sometimes surprised to find ourselves composing simple melodies that are never finished, and are major or minor according as we are gay or sad, while we may be totally ignorant of the existence of those modes. Some natures seem obliged thus to express themselves in song. This is because speech is really an imperfect means of expressing the feelings. It is just as necessary to address the feelings, to make an emotion known, as it is to address the intellect, to communicate an idea. Hence the charm of the opera, in which the words describe the situation, while the music enables us to see into the hearts of the persons who are implicated in it. A certain school of operatic composers, indeed, are not concerned about depicting the passions set forth in their dramas, but are satisfied if they can introduce a few agreeable melodies good to sing anywhere and to any words, and which will become favorites; but this is not the case with real dramatic music as illustrated in the works of Gluck, Berlioz, Meyerbeer, Rossini, Verdi in his second style, and Wagner.

In songs, the expression is in an inverse ratio to the interest of the words. Good poetry is hardly susceptible of any but an uncolored music, just enough to sustain the voice; the thought, in effect, crowds out the feeling, and, a choice being forced upon the attention, too much musical accent would weaken the thought. For a full musical interpretation of the feeling, a third-rate poetry, only indicating the subject, is best, for it permits the concentration of all the attention upon the emotional expression. This is, ordinarily, the character of the librettos of operas, in which everything is subordinated to the music; but the song, the interest of which lies in the conception, is accommodated with a colorless melody.

By considering music as the language of the feelings, we are enabled to account for the power it has over masses composed of the most incongruous elements. An address can not affect alike persons of different degrees of intellectual development, and must fall without making any impression on a part of the audience. There is less difference in the capacity for feeling, and all are more or less subject to the same transports of emotion. The masses feel more than they think.

It is interesting to remark the generally simple and touching expression of popular songs. The feeling is brought out in its purity without science or preparation, and the result is a music full of artless charms, the inexhaustible source to which composers, knowing that they can not find better ones, go for the themes of their works. These popular songs are generally of a sad character, and tell of vague aspirations and indefinite desires. Thus have originated those dreamy melodies with which working-people love to lull their melancholy, and which are frequently the only source to which we can go for the history of those who have lived and suffered in obscurity.

As different human races have their several languages, so each one has its own musical system; and these various systems, the existence of which is explainable by the action of the same causes that have made different words to designate the same things, prove that the origin of the two languages is common, and that the one is the spontaneous expression of feelings, as the other is of thoughts. Like alphabets, gamuts also may differ within certain limits. They are also not fixed, and undergo the evolution common to all languages. Most uncivilized peoples are unacquainted with semitones, and use scales with full intervals. This is easily accounted for if we suppose that these intervals are the ones which represent the elementary intonations, and that they constitute a music near its origin. The need of representing shades of feeling brings about a progressive filling up of the intervals. The ancient Celts excluded semitones, while the music of the Greeks found refined expression in quarter-tones. Our musicians are also sometimes tempted to reduce our minimum interval of a semitone, and some performers abuse this process to an extravagant degree.

The effect produced upon our ear by music of a system different from ours is generally painful; but we have no right to say that the Indians and the Arabs sing false. We have to learn a language to understand it; and a quite short accustoming is generally sufficient for a music that appeared savage and harsh, at the first hearing, to become supportable, if not agreeable.

Music nearly always commands the attention of animals; and every one knows what curious results have been obtained from experiments on different species, from the elephant to the spider. This language of feeling is really more within their reach than speech; and we may generally remark that when we address ourselves to our domestic animals it is by the intonation alone, of greater or less force, that we make them understand—that is, feel. Articulate words have no meaning for them, except on condition of a previous education based on the association of sensations. A dog is never mistaken as to the intention of a person calling him, and the tone alone tells him whether a caress or correction is in waiting for him. So music is never heard by animals with indifference.

After what has been said it would be idle to consider the rank which music holds among the other arts; its origin, its nature, and its effects give it a separate place. It is a language which everybody understands, which nearly all speak to some extent, and in which some rise to a sublime eloquence.

Poetry, with its measure and rhythm, is the first intermediary between speech and music; but it lacks vastly the power of the latter, because of the degree of intellectual culture it exacts. Mimicry comes nearer to music in its effects, for it leaves the idea vague, and speaks more directly to the feelings; and it is a great aid to the orator. But the most powerful orator is he who has a musical intonation.

An interesting investigation might be made of the various musical accents which answer to different conditions of feeling. To ascertain this correctly would require a long and minute course of experiments. It is curious to observe, however, that Gluck, Mozart, Berlioz, Meyerbeer, and Wagner, when they have the same situations to depict, whether in recitative or melody, use the same musical intonations. It thus appears that the major third is generally employed in interrogations and appeals, and that the appellative character of that interval becomes more marked and impressive in the fourth descending, while the fourth ascending denotes affirmation, decision, command. The minor and major fifths express the feelings from prayer to violent desire and menace. The sixth is the interval of passion; it is the symbol of a very accentuated emotion, and is inevitably met where love is declared. A semitone higher conveys the idea of something painful, which is resolved into a real expression of grief in the cry of the seventh, the symbol of an excess of suffering. There are, in

effect, no two ways of saying the same thing in music, and it is only in the way the phrase is introduced and sustained by the harmony that authors vary. We are speaking, of course, only of those passages of the songs in which the emotions are exploded, for it is in these only that the author, not caring to expend his force over the whole phrase, aims to bring out his full meaning. From these comparisons of emotions and intonations we are able to discover the physiological reason of the correspondence between the note and expression. The smaller intervals are congenial with indifference, monotony, doubt, melancholy, and sadness; the group of moderate intervals affirms occupation, pleasure, and desire, which grow more ardent as we approach the extreme intervals; and in these we look for the most intense feeling. Melancholy sentiments involving diminished vitality, we might naturally conceive them to be expressed musically by diminished intervals, the compass of which requires little effort; while earnest desires, strong passions, and pleasant and happy feelings, being accompaniments of a more active vitality, provoke more vigorous expressions; and these expressions, by giving an outlet to the excess of vitality, furnish one of the best means for calming violent passions.

We add a few words on the nature of musical pleasure. It is dependent on variety—the essential condition of all pleasure, that of the mind as well as that of the senses; variety of ideas for the former, variety of sensations for the latter. Nothing, in fact, is more incompatible with pleasure than monotony, even in agreeable things. The feelings do not escape this general law; and the cause of musical enjoyment must be sought in the infinite variety of conditions of feeling through which the rapid succession of musical intervals makes us pass. In this, we do not speak of the merely material pleasure of the sense of hearing, which may exist aside from all attention; but of the stirring up of the whole being by the emotions. To this enjoyment, which exists parallel with the succession of sounds, should be added the pleasure of the hearer's adapting his personal feelings of the moment to the general sense of the performed music: a theme marked with melancholy will move a whole audience of thousands to sadness, each person of whom will associate his feeling with some particular object. This impersonality of the musical phrase and its adaptability to individual feelings explain the taste of the masses for music, and its power over them. The system of tones, by furnishing a kind of stable basis for the undulating variety of musical sounds, effects in music a union of the two chief conditions of pleasure—variety in unity.

It is impossible to treat of music without speaking of rhythm, which, without being an essential part of it, enframes it, sustains it, and gives precision to its otherwise vague expression. The origin of rhythm need be sought no further off than in the movements and paces of men. Descartes finds it in the efforts of the voice in sing-

ing, or the gestures of the instrumentalist; every accent is preceded by an inspiration or a drawing of the bow, marking the beginning of a new effort. These efforts, methodically arranged, give musical measure.

Different rhythms reflect the different paces of the walker or the rider plainly enough to justify us in attributing their origin to them. The same cause that makes one pace his room with gaits varying according to the impressions of the moment, in the reverie of solitude or in conversation, also determines the rhythm in music.

Just as our emotional being loves to be amused by rhythms suggesting natural outer movements, so certain cadenced sounds casually heard, such as that of a passing train, the trotting of a horse, or the beating of oars, induce states of sensibility, under the influence of which we surprise ourselves by humming old airs, or by improvising melodies that naturally adapt themselves to the fortuitous movement.

This conception of the origin of music explains the universality of its domain and its power, as well as all the particular facts connected with its different adaptations.—*Translated from the Revue Scientifique.*

IS FINGAL'S CAVE ARTIFICIAL?*

By F. COPE WHITEHOUSE, M. A., etc.

IN venturing to ask a question and thus imply a doubt upon a point on which geologists, statesmen, and poets have given their consentient opinion for a century, it is not without regret that an opinion, held without suspicion of challenge, should be subjected to criticism, and better proof than prescription required for the title by which this celebrated cavern has been held and enjoyed as the work of Nature.

The process of reasoning which led me to believe that the cavern owes its existence to the hand of man had little in common with the arguments by which the inference is now supported. In June, 1881, while examining the Giants' Causeway, it seemed evident that columnar basalt showed no tendency to erode and form hollows. Where the basalt, which for the height of some hundreds of feet above the chalk is quite amorphous, and caps the low promontories along the coast, is brought so low that more than one half of its thickness is immersed in the sea, the remainder projects above the water and forms the well-known natural pier. The caves on that coast are in the great

* A summary of an address made before the American Association for the Advancement of Science at Montreal, August 30th, and the Academy of Science at New York, October 9, 1882, illustrated by photographs and diagrams.

ochre-bed or chalk. They are plainly artificial in their present form. The peculiar Gothic door-way and the sheltered approach strengthen the view that they bear a distinct relation to an ancient civilization, and that it is not by accident that adjacent cliffs are crowned with castles, neighboring mines were worked from unknown periods, beacon-rocks bear mythological names, and manuscripts refer to maritime expeditions to the Baltic and Mediterranean. It seemed antecedently possible that the same race, Kelto-Iberian, Wend, or Phœnician, which had formed harbors on the coast of Ireland, might also have been the active agent in that perforation which has been termed the most remarkable in Europe. This conjecture received strong and unexpected confirmation. It was submitted to rigid examination; it was strengthened by opposition. It has been adopted, by a considerable number of eminent men, as a far stronger *prima facie* case than that commonly stated by the text-books in favor of marine erosion. If not well founded, it still suggests difficulties which have escaped observation, and may also correct the inaccurate terms in which Fingal's Cave has been described, and the imperfect representations which have gone far to perpetuate the hasty conclusion of Sir Joseph Banks.

Fingal's Cave is not at the Giants' Causeway. It is in the southern end of the Island of Staffa, whose apparent size and position are necessarily exaggerated on the maps in common use. It is not "off the

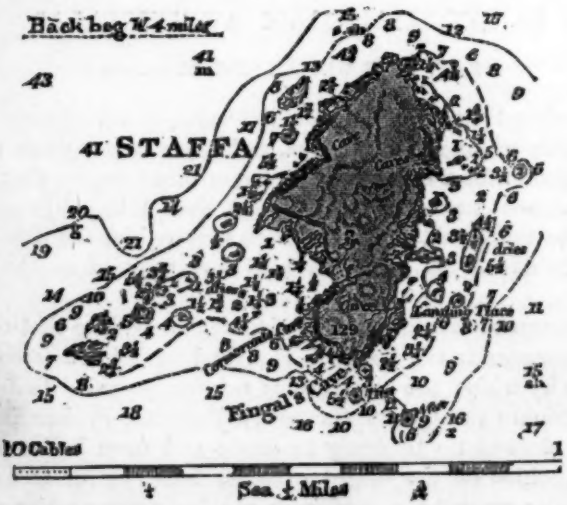

FIG. 1.—FROM THE ADMIRALTY CHART OF LOCH TUADH.

southwest coast of Scotland." It is deeply embayed in a large sinuosity formed by the Island of Mull, and nearly inclosed on the opposite side by Iona and the Treshnish Islands. Beyond the latter a second line is drawn by Tiree and Coll, while to the north but to a greater distance are placed the islands of Minch, Rum, Eigg, and Canna. The

circle is completely closed for 315° by land, distant at farthest from five to seven miles. From Dutchman's Cap, bearing nearly due west, to the "Stac" off Iona, there is comparatively deep water of forty to fifty fathoms. The charts, however, show that rocks approach the surface. "Five-Fathom Rock," "Dangerous Overfalls," and soundings of less than ten fathoms, push half-way across the Passage of Tiree. Mackenzie's Rock, which dries in four feet, guards the other entrance, and no Atlantic surge could pass into Loch Tuadh or the Sound of Iona, without changing its direction twice and almost at right angles. But Donegal receives the impetus of the tremendous billows which break against the steep cliffs of Mizen Head, or rush up the narrow gorges with which the exposed coast of the Northern Hebrides is so deeply scored. Staffa is singularly sheltered. It makes it antecedently extremely improbable that this particular spot would be selected by the ocean as a place on which to "prove its strength." Wordsworth was both a landsman and a poet, and, as he says—

> "In a motley crowd, each the other's blight,
> Hurried and hurrying"—

only *saw* it. His language, however, has undoubtedly been made a vehicle of scientific error.

"Caves worn by the sea are due to the set of the currents, the force of the breakers, and the grinding of the shingle, which inevitably discover the weak places in the cliff, and leave caves as one of the results of their work, modified in each case by the local conditions of the rock" ("Encyclopædia Britannica"). Assuming that this is a complete statement of the law of marine erosion, how was Fingal's Cave "hollowed out of columnar basalt," and therefore rightly classed by Professor Boyd Dawkins, "among caves worn by the sea"? There is no current setting into this bay. The spring tides rise 11¾ feet, neaps 8 feet, and range 4½ feet. The maelstrom of that part of the ocean is "where Corryvrechan's surges driven" make "the caldron of the spectral sea," but to the south, behind Colonsay. The force of the breakers is inconsiderable. Either they are the result of local disturbance formed to the east of Tiree, or the ground-swell and heaving of the sea after a storm. The island is fully protected by its own foreshore. The perpendicular columns suggest an "unknown profundity of depth." But the basalt on the west is over 50 feet above the sea-level. A spit of conglomerated trap or tufa prolongs under water a flat, rocky shore. There is a succession of rocks and shoals. The 20-fathom line is a mile distant, the 10-fathom half a mile, immediately followed by rocks, and 12, 15, and 9 feet of water. As the cave is in the southern face, it appears to be impossible, in the present state of the coast, that a wave with any momentum could strike directly upon that end of the island. As MacCulloch sat on one of the columns, though the long swell raised the water at intervals to his feet, the movement was silent, and the surface of the sea apparently undisturbed. There is

FIG. 2.—WEST SIDE OF STAFFA, 1863. G. W. W. SHOWING ARCHED ENTRANCE TO CORMORANT'S CAVE.

no shingle. The prismatic blocks are refractory. If a wave struck with sufficient force to dislodge the drums, or if, undermining the tuff, it strewed the beach with hexagonal or pentagonal blocks, these smooth stones, with polished sides, buried in the finer material, would offer very great resistance to any further waste of the cliff. Although a channel of 18 feet at mean low water approaches and enters the cave, there is no ledge over which the material could have been carried. The sharp conchoidal fracture would not serve the purpose of such crystalline rocks as quartz or granite, and furnish the fluid wave with a serrated edge.

The cave is not formed in what would naturally be considered *the* cliff; least of all in its weakest place. After examining the Admiralty Chart, "the reader will, no doubt, pass with pleasure to the rich description by Dr. MacCulloch." That author, however, says that the whole of Fingal's Cave seemed like a ship heaving in a sea-way, and therefore his survey may be considered less trustworthy than that of Commanders Bedford and Creyke (Admiralty Chart, 1857). It seems incorrect to say, "The caves are so numerous that they may be said to perforate at brief intervals the whole face of the island; but those which

occur on the south (*sic*, query west) and the north sides are remarkable neither for beauty nor for magnitude." The caves are sufficiently numerous to furnish an argument. There are very few hollows worn by the sea in the Scotch coast. The islet, which contains a dozen, has not the $\frac{1}{100000}$ part of the indented line of the mainland, and bears an infinitesimal ratio to the sea-board, including the islands. Its parent, Mull, within whose bosom rests this irregularly oval rock, "measuring about one and a half mile in circumference," has in the dimension of length one hundred and fifty times better right to a "museum of wonders." The "Isle of Columns" is a speck too tiny to show on any ordinary map. The chance that it would contain, as a legitimate yet exceptional result of normal contact between igneous rock and sea-water agitated by wind, "the most remarkable cave in Europe," is less than 0. It is the $\sqrt{-1}$.

The uneven table-land is formed of "three distinct beds of rock of unequal thickness, inclined toward the east at an angle of about nine degrees. The lowest is a rude trap tufa, the middle one is divided into columns placed vertically to the plane of the bed, and the uppermost is an irregular mixture of small columns and shapeless rock." The columnar bed is never more than 60 feet thick. The island itself attains a maximum height of 129 feet. It has no peak from which rain-water might descend in a considerable quantity. There is no series of fissures corresponding to the perforations. There is nothing on the flat top to suggest the tunnels beneath. Proceeding toward the south from the landing-place, there are six cases of alleged erosion, each presenting its own seemingly insuperable difficulty, and cumulatively requiring a more thoughtful and serious consideration than the fantastic phrases in which 'stupendous (!) columns, three feet thick and thirty feet high, rise from a *dark-red* or violet-colored rock over which *the ocean* rolls, and reflects from its *white* bottom a variety of *crimson* and *yellow*.'

It appears now to be well established that the peculiar structure of columnar basalt is due to contraction and splitting consequent upon cooling. The analogy is rather to the splitting often seen in the mud bottom of a dried-up pool than to ordinary crystallization. The various conditions point to the contractile origin of the structure, at the same time that the result suggests a curious mimicry of imperfect crystallization. If the cooling mass of basalt be in one of its vertical sections of such a form that successive isothermal *couches*, taken in descending order, are not parallel to the original cooling surface, as they are in all cases of straight and parallel prisms, but divergent gradually from the cooling surface and from each other, then the lines of the splitting of the prisms, always true to these *couches*, must be curved in one direction. This will be true, whether the isothermal *couches* be plane surfaces divergent from a thinner to a thicker part of the mass, or whether they be curved surfaces arising from the mass reposing on

a curved bottom and diverging in like manner. The *crux* of Staffa is Scallop or Clamshell Cave. Inattention has caused the various authors to describe it as if there was nothing astonishing in the sudden interruption of the columns, which are "bent so as to form on one side a

FIG. 3.—FINGAL'S CAVE, STAFFA, 1111. J. V.

series of ribs not unlike an inside view of the timbers of a ship," while "the opposite wall is formed by the ends of columns, and bears a general resemblance to the surface of a honey-comb." Sixteen feet wide,

130 feet long, how could the sea attack the landward, southeast end, and carve a trench 45 to 50 feet deep, where it is geologically impossible that a "fault" or "weak place" aided the natural force? The channel of Bouchaillie, seen from the cliff above, is a canal cut through the columnar basalt, and taking a slice from that conoidal pile of columns about thirty feet high, which is seen a few yards to the right of the Colonnade and Fingal's Cave. Where is the *débris?* Why should it be crossed at right angles by the passage leading into the Clamshell Cave? The Causeway here presents an extensive surface, which terminates in a long, projecting point at the eastern side of the Great Cave. It is formed normally. The heads of columns show in a compact and serried phalanx. Each row protects the other in turn. The tesselated pavement, as on the Irish coast, is a firm, impenetrable mass, showing by its steepness its utter contempt for the wavelets which could not break those ranks in a geological æon. There is nothing to prepare the scientific mind, distrustful of abrupt changes, for the adjacent excavation. Its dimensions are, from the top of the arch to the cliff above, 30 feet; to the water, 66 feet; to the bottom, 88 feet. Its breadth of 42 feet continues to within a small distance of the inner extremity, when it is reduced to 22 feet. The total length is 227 feet.

It is usually said to have been formed by erosion at the base. The columns, falling, dragged down a part of the roof, aided by a fissure which divides the ceiling. The tuff is not eroded even at the southwest end of the island. These pillars, however strong and enduring, are each composed of many separate joints or pieces, built up one upon another. They do not adhere in any way together, but merely rest mechanically upon each other, and are easily detachable. The capitals beyond cling to the roof. There is no fissure. In Boat Cave, tuff is undermined for 1,800 square feet, yet the columns stand wedged across 12 feet of width. At Tanaga Island, in the Aleutian group, the broken columns form a slightly *convex* roof across an opening 20 feet wide. No such Gothic arch was ever formed by Nature. It is strikingly Phœnician. No natural cave has an entrance higher than the interior. A tidal or earthquake wave would not reach the top of the arch. The cave is post-glacial. The upheaval of that part of Scotland is put at 25 feet. It would not bring the confused basalt within reach of the waves. Their breaching power is easily calculated. It is determined in this case by the frail wall to the east. For a merciless ocean selecting this victim of his fury, and

> "Down-bearing with his whole Atlantic weight
> Of tide and tempest on the structure's base,"

and "flashing to that structure's topmost height," in his blind frenzy would have swept through the loose drums to the right. Montalembert thought it far inferior to any cathedral, or even a monastic church such as Cluny or Vezelay. If "raising (!) a minster," it would have

been better to put all the chapels under one roof. The horizontal and perpendicular sections are equally at variance with the curved surface formed by a fluid in vibration. The columnar basalt would form a

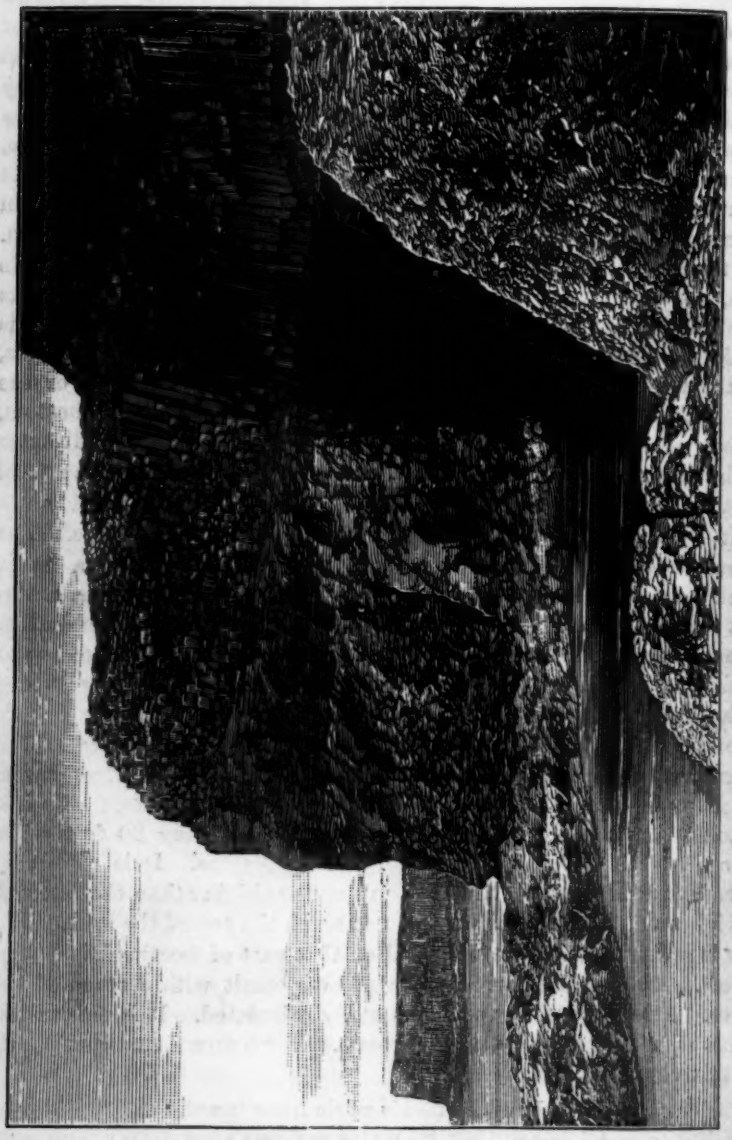

FIG. 4.—CORMORANT'S CAVE, STAFFA, 1861. G. W. W.

curved and not a rectangular water-line. What other cavern has a uniform breadth from the opening, and five and a half diameters in length?

Cormorant's or Mackinnon's Cave is easy of access, and terminates

in a "gravelly" beach, where a boat may be drawn up. It is 50 feet high, 48 feet broad, and 224 feet long. It is excavated in the lower stratum. Thus two tunnels of the same dimensions are supposed to have been driven into two different materials by the same force. The interior dimensions are nearly the same to the end. As no sentimental or religious motive can be assigned to Nature for *this* freak, it is amenable to comparison. The Blue Grotto of Capri is typical. Its entrance is scarcely three feet in height; in the interior the roof rises to a height of 41 feet; the water is 8 fathoms deep; length of the grotto,

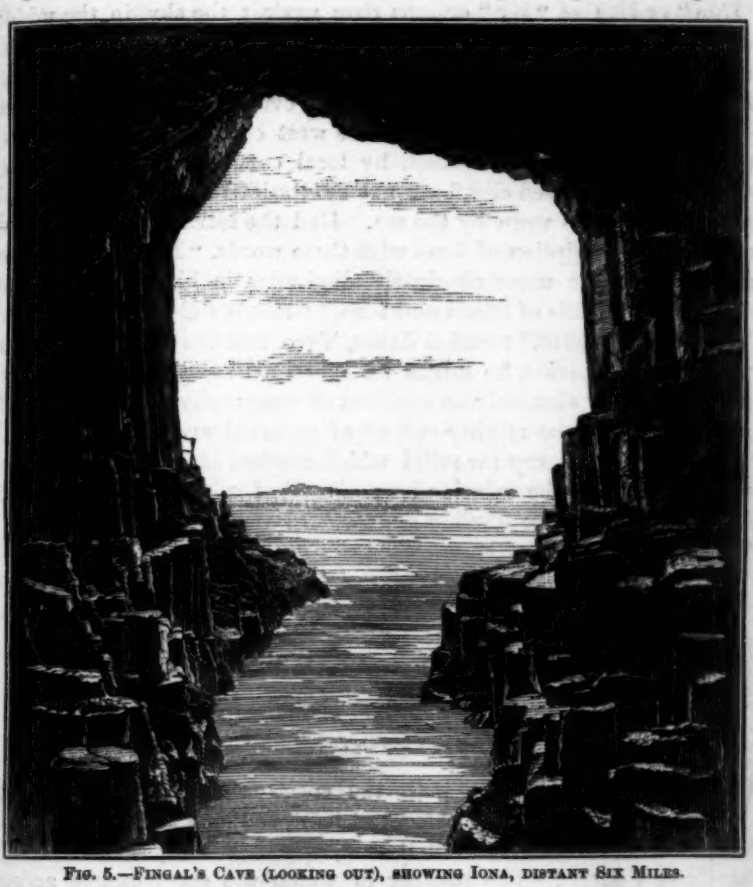

FIG. 5.—FINGAL'S CAVE (LOOKING OUT), SHOWING IONA, DISTANT SIX MILES.

175 feet; greatest width, 100 feet. Here the great size of the aperture is further increased. The superior part of the front, penetrating into the columnar basalt, has hollowed a recess above the main opening. The same Gothic tympanum, distorted by the material, not only marks its artificial origin, but disproves the allegation that the columns could not form a natural architrave. The Boat Cave is accessible only by sea. It is a long opening, resembling the gallery of a

mine, excavated also in the tuff. Its height being about 16 feet (above the sea?), its breadth 12, and its depth about 150, it offers, in its proportion of twelve and a half diameters, the greatest contradiction to all other instances of sea-worn homogeneous rock.

But not only do Cormorant's and Fingal's Cave, each protected by its breakwater, face the adjacent land and not the open sea, and that land the far-famed Island of Iona, center of art and civilization, "dear to Christendom for more than a thousand years," but from the end of this deep cavity, to which a boat may sail in any ordinary weather, the "Dun" or Hill of "Hy" or Iona rises against the sky, in the middle of the arc of a few degrees subtended by the grand doorway. Until it is shown that a thousand yards of landlocked, iron-bound coast can be cut and tunneled in utter disregard of every known law of mechanical action, the caves in Staffa, on the west coast of Scotland, driven into igneous rock, not modified by local conditions, or in the weak places "of an exposed cliff," can not be classified as merely remarkable instances of caves worn by the sea. Had the learned duke who commenced his description of Iona with these words, "No two objects of interest could be more absolutely dissimilar in kind than the two neighboring islands of Staffa and Iona," "mixed Celtic memories with the Phrygian mount," recalled Athos, Tyre, and Carthage, or even the twin Island of Lerins, he might have hesitated to put them in sharp antithesis to say that only an accident of geography could unite their names, or with "the mighty surge" of personal and social authority drowned the faint cry for relief which reached his ears, and declined even to consider the solution here offered of a problem whose complex factors he had so forcibly stated.

THE SPECTROSCOPE AND THE WEATHER.

By C. PIAZZI SMYTH,
ASTRONOMER ROYAL FOR SCOTLAND.

WHAT may be done with the spectroscope in the matter of weather is, for the present at least, confined almost entirely to the question of rain—as, Will it rain, or will it not; and, if it will, heavily or lightly? The manner in which the spectroscope accomplishes this useful part is by its capacity for showing whether there is more or less than the usual quantity of watery vapor permeating the otherwise dry gases in the upper parts of the atmosphere, this watery vapor not being by any means the visible clouds themselves, but the invisible water-gas out of which they have to be formed, and by means of which, when over-abundant, they obtain their privilege for enacting rain-fall. So that never were wiser words uttered and more

terse philosophy than those which are to be found in the ancient book of Job, wherein, of the wondrously "balanced clouds" high up in mid-air, it is said, "They pour down rain according to the vapor thereof."

More or less of this water-vapor is always in the air, even on the very clearest days, and a happy thing for men that it is so; for, as Dr. Tyndall and others have well shown, it moderates the excesses of hot solar radiation by day and cold radiation of the sky at night, and is more abundant in the hotter than in the colder parts of the earth. Wherefore, according largely to its temperature for the time being, the air—otherwise consisting almost entirely of nitrogen and oxygen—can sustain, and does assimilate, as it were, a specified amount of this watery vapor, invisibly to the naked eye, the microscope, or the telescope; but not so to the instrument of recent times, the spectroscope. And if the air vertically above any one place becomes presently charged with more than its usual dose of such transparent watery vapor (as it easily may, by various modes and processes of nature), the spectroscope shows that fact immediately, even while the sky is still blue; clouds soon after form, or thicken if already formed, and rain presently begins to descend.

But how does the spectroscope show to the eye what is declared to be invisible in all ordinary optical instruments? It is partly by its power of discriminating the differently colored rays of which white light is made up, and partly by the quality impressed on the molecules of water at their primeval creation, but only recently discovered, of stopping out certain of those rays so discriminated and placed in a rainbow-colored order by the prism and slit of the spectroscope, but transmitting others freely. Hence it is that, on looking at the light of the sky through any properly adjusted spectroscope, we see, besides the Newtonian series of colors from red to violet, and besides all the thin, dark Fraunhofer, or solar originated lines, of which it is not my object now to speak, we see, I say, in one very definite part—viz., between the orange and yellow of that row of colors, or "spectrum," as it is called—a dark, hazy band stretching across it. That is the chief band of watery vapor; and to see it very dark, even black, do not look at a dark part of the sky or at black clouds therein, but look, rather, where the sky is brightest, fullest of light to the naked eye, and where you can see through the greatest length of such well-illumined air, at a low, rather than high, angle of altitude, and either in warm weather, or, above all, just before a heavy rain-fall, when there is and must be an extra supply of watery vapor in the atmosphere. Any extreme darkness, therefore, seen in that water-vapor band beyond what is usual for the season of the year and the latitude of the place is an indication of rain-material accumulating abnormally; while, on the other hand, any notable deficiency in the darkness of it, other circumstances being the same, gives probability of dry weather,

or absence of rain for very want of material to make it; and the band has, therefore, been called, shortly, "the rain-band." Thus, also, "rain-band spectroscopes" have been specially constructed by several most expert opticians in size so small as to be carriable in the waistcoat-pocket, but so powerful and true that a glance of two seconds' duration through one of them suffices to tell an experienced observer the general condition of the whole atmosphere. Especially, too, of the upper parts of it, where any changes—as they take place there almost invariably earlier than below—enable such an observer to favor his friends around him with a prevision of what they are likely soon to experience.

As an example of what may be done, and done easily, after a certain amount of experience and understanding of the subject has been acquired, I append, from a lady's meteorological journal, her notes of the mean temperature of the air and the intensity of the rain-band for each of the first fifteen days of the present month, and in a final column have entered the amount of rain-fall measured at the Royal Observatory, Edinburgh, on each of those davs. The darker the rain-band the larger is the figure set down for it, and it will be seen pretty plainly, on running the eye down that column and the next one, that with an intensity of either 0 or 1 no rain follows, or, we might almost say, can follow; but with an intensity of 2 rain-fall begins, and with 3 it may be very heavy. All these rain-band notes have been made with a spectroscope no larger than one's little finger, purchased some six years ago, and taken on many voyages and travels since then:

DATE, SEPTEMBER, 1882.	Mean temperature of the air.	Rain-band intensity.	Depth of rain measured in gauge at Royal Observatory, Edinburgh.
	Deg. Fahr.		Inch.
Friday, 1	57·1	3	·044
Saturday, 2	59·2	2	·353
Sunday, 3	58·6	2	·015
Monday, 4	54·4	0	0
Tuesday, 5	55·7	1	0
Wednesday, 6	55·2	0	0
Thursday, 7	53·8	1	0
Friday, 8	59·4	0	0
Saturday, 9	54·0	1	0
Sunday, 10	57·0	1	0
Monday, 11	52·2	1	·040
Tuesday, 12	48·6	0	0
Wednesday, 13	52·8	1	0
Thursday, 14	49·5	3	·62
Friday, 15	56·2	2	.570

But, if so much can be done by so small a spectroscope, the question may be well asked whether more still might not be accomplished with a bigger and more powerful one, especially seeing that the dispersive powers of both chemical and astronomical spectroscopes have

in late years been increased to a most astonishing extent. The question is important, and somewhat new as well. I propose, therefore, to devote the remainder of my space to its answer, rather than to the practical rules for using the smaller instruments, especially, too, as they have been already introduced to the public, both by my friend Mr. Rand Capron, in his pamphlet "A Plea for the Rain-band," and by myself, in the fourteenth volume of the "Edinburgh Astronomical Observations"; also in the "Journal of the Scottish Meteorological Society," and in the September number of the "Astronomical Register for 1877."

The greater part of higher power spectroscopes are not suitable to rain-band work, for their fields are usually too dark. But having recently built up for myself a large-sized variety of the instrument, possessing perhaps the greatest combination of power with transparency yet attained, and having it always mounted in an upper chamber looking out at an altitude of about 5° over the northwestern horizon (or most suitably for rain-band work), I will try to describe shortly its action therein.

The classical "rain-band," which in the little instrument is merely a very narrow fringe to an almost infinitely thin black line, is so magnified laterally in the larger instrument as to fill the whole breadth of the field. The thin black line before spoken of is now not only split into two, but these are both strong, thick, sharply defined lines, separated from each other by six or seven times the breadth of either. These are the celebrated solar D-lines, D1 and D2, arising from the sodium metalloid burning or incandescent in the sun. They are, therefore, perfectly uninfluenced by changes of the terrestrial atmosphere, hot or cold, wet or dry, and are, therefore, invaluable as references for degree of visibility of the water-vapor lines and bands which rise or fall in intensity precisely with those changes. There are several of these earthly water-vapor lines and bands in and between and about the D-lines themselves; then a long breadth of band toward the red side of D1; then a pair of lines not so widely apart as the D-lines, but sometimes just as sharp and black; then two or three fainter bands; then a grand triple, of which the nearer line sometimes attains greater blackness than either D-line; then beyond that three distinct, equal-spaced, isolated bands; and, farther away toward the red, a stretch of faint haze and haze-bands.

All these go to make up the one thin rain-band of the little spectroscopes; and I fortunately had, through the month of August and the early days of September, occupied myself each morning in noting the greater or less intensity of each and all these water-vapor lines and bands in terms of the two solar constants D1 and D2; and every such morning there was an abundance of details to see, to recognize, and to measure. But on the morning of Monday, September 4th, when the little instrument had truly enough marked 0 on its very small scale,

I almost started at finding in the large instrument every member of its long rain-band group, unless it were a vanishing trace of one or two of the strongest, utterly gone; while the two D-lines were in their accustomed strength, but far greater clearness, for now they were all alone in the field save the ultra-thin solar nickel line between them and one or two others, equally thin and solar on their blue side. The stages of perceptible shade of water-vapor lines which had thus been swept away, between their this day's invisibility, and their tremendous strength no longer before than the previous Friday, might have been expressed by a scale not divided into three parts only, but into thirty; and implied such a very unusual amount of absence of water-vapor, that I not only felt sure of no rain falling either next day, or perhaps for several days after, but that the weather must also be coming on colder as well. Therefore it was that I took the step of instantly writing as I did to a local paper, promising the perplexed farmers dry weather at last, though probably sharp and cold, to get in their crops.

And how was that expectation fulfilled? Various meteorologists in different parts of the country have already declared themselves well satisfied with it. But I would now beg further attention to the little daily register already quoted, showing that from and including that day, Monday, September 4th, up to and including the next Saturday, not a drop of rain fell at the observatory. Between the following Sunday and Monday, a drizzle, but only amounting to 0·04 inch, occurred, and after that there were three more days equally dry with the preceding ones. But on Thursday, the 14th, the rain-band reappeared in both spectroscopes in all its force; rain began to fall the same day, and next day's measure at the observatory amounted to more than half an inch. Wherefore it is to be hoped that the farmers had busied themselves effectively while the dry weather lasted, for the return of these spectral lines of watery vapor showed that their autumn opportunity was then gone by.—*London Times.*

CRIMINALITY IN ANIMALS.

By A. LACASSAGNE,

PROFESSOR OF LEGAL MEDICINE IN THE FACULTY OF LYON.

IT is a recognized fact that the anatomy and physiology of animals have afforded valuable help in the study of the human constitution. We might, indeed, say that physiology, toxicology, and therapeutics are based upon experiments which have been made on animals. Why, then, have we halted at this stage? Why has it not occurred to medical experts in criminal law to study the phenomena of crimes

among animals for the purpose of reaching a better understanding of those which are committed by men? If animals are liable to the greater proportion of the organic maladies to which we are subject, if they are liable to epidemic or contagious diseases, there appears to be no reason why they should be exempt from mental diseases. Just as we recognize that there occur among men malformed individuals, organically defective and furnishing proofs of their organic faults in their acts, feelings, or thoughts, so we should expect to find similar individuals among animals, or at least among those species which stand constitutionally nearer to man.

Two causes may be alleged for the neglect of this study: First, animal psychology has not yet made much progress. The investigations of veterinary physicians have not been directed to that side. Pierquin said, in his "Traité de la Folie des Animaux" (Treatise on Madness among Animals), in 1839, that till his time no professor of veterinary medicine had ever spoken from his chair, either of the brain, the nervous system, or the physiology of animals. The other cause, and the most influential one, has been the difficulty most authors have had in disembarrassing themselves of the scholastic ideas which have promoted the belief in a great chasm between the moral condition of animals and of men. As Gall has well said, the greatest obstacle that it has ever been possible to oppose to the knowledge of human nature consists in the fact that theorists have isolated it from that of other beings, and endeavored to subject it to laws of its own, different from those of their nature. He adds, subsequently: "Those who account for the normal and intellectual acts of man, of the understanding and of the will, independently of the body, and those who, being wholly strangers to the natural sciences, still believe in the mechanism or the automatism of brutes, may find the comparison of man with animals revolting and absolutely sterile. But such a comparison will be regarded as indispensable by those who have familiarized themselves with the labors of Bonnet, Condillac, Reimarus, Georges Leroy, Dupont, Nemours, Herder, Cadet Devan, Huber, etc., and especially by those who have become ever so slightly acquainted with the progress of comparative anatomy and physiology."

The authors who are cited by Gall have furnished important data for the comparison of animal species, and have laid the foundation of a scientific comparative physiology. Buffon had already asserted that, if no animals existed, the nature of man would be still more incomprehensible than it is. The observations of Georges Leroy and Gall have shown that the elementary functions of the brain must be investigated in the study of animals. These authors have been followed in this way by Prichard, Pierquin, Darwin, Forel, Espinas, Houzeau, Büchner, etc., from whom and from other naturalists and travelers, the materials for this essay have been largely borrowed.

The present work was suggested to me by Professor Lambrozzo, of

Turin; and Professor Cornevin, of the veterinary school of Lyons, has furnished me several valuable facts.

By way of an historical introduction to our study, we will cast a glance at the relations which the human laws of different societies have established between men and animals. The primitive peoples, fetichistic in their feelings and habits, and not yet capable of metaphysical subtilties, instinctively put animals and men upon a footing of perfect equality as respected the penalties to be attached to their crimes. It was so with all people during the middle ages, and even in fact down to the last century. Then, by one of the sudden contradictions which frequently appear in the history of mankind, a distinction between the actions of men and of animals was clearly defined. The powerful influence of Descartes, the encyclopedists, and the scientific men of the last century, who were more frequently demolishers than constructors, affords the explanation of the change, which, it is proper to say, was due rather to bad than to generous sentiments. Gradually, under the domination of the metaphysical spirit, the conviction arose that animals were brutes, that it was difficult to appreciate their moral state, and that this moral state was after all separated, if it had any existence, by an immense distance from that of man. So the law protecting animals was quite forgotten in the framing of our codes.

Only a few scientific men or observers made approaches to the admission of evolution and transformation. These ideas have become common now, and nearly every one has adopted them theoretically, but few admit them in practice, and it will not be surprising to us if the title of our essay raises a smile on the face of many of its readers.

We will begin by showing how the human societies that have preceded ours have manifested their feelings with regard to certain acts of animals. Among fetich-worshiping peoples, the animal is considered as a man, and a member of the human family to the same extent as a slave. Its loss is an occasion for mourning, and its trespasses—toward man—deserve punishment.

In ancient Egypt, when a cat died in the house, the inhabitants shaved their eyebrows; if a dog died, they shaved their whole body. In Athens, one of the laws of Triptolemus declared that no one had a right to inflict a wrong upon a living creature. The Greeks were aware of the tender and affectionate care which the young of the stork exhibited for their old parents, and recorded that, when the latter lost their feathers from age, the young stripped themselves of their down for them and fed them with the food they collected. This was the origin of the Greek law called "the law of the stork," by virtue of which children were obligated to take care of their aged parents, and those who refused to do so were declared infamous. How different is it in our modern societies! Pierquin remarks with reason that, as man rises, he treats animals as if they were correspondingly degraded.

For a long time they had the same rights. During the middle ages they were allowed a part in religious ceremonies. At Milan they figured in the festivals of the kings; and processions of animals appear in the bas-reliefs of the cathedrals of Strasburg, Mans, and Vienne (Isère). On Holy Wednesday all the clergy of the church of Rheims went to Saint Remi to make a station there; the canons, preceded by the cross, were arranged in two lines, each drawing a herring after him with a cord; and each one was intent upon saving his own fish, and stepping upon that of the canon in front of him (Anquetil, "Histoire de Reims"). At Paris, the procession of the fox was as much enjoyed as the festival of the ass. The animal, dressed in a kind of surplice, wearing the mitre, had his place in the midst of the clergy: a fowl was put within his reach; he often forgot his pious functions to spring upon the bird and devour it in the presence of the faithful. Philip the Fair was very fond of this procession (Sanval, "Antiquités de Paris"). Only a few years ago, the procession of the fat ox remained, a survival from the pagan feasts, a real piece of wreckage from vanished civilizations.

While the rights of animals were thus recognized, their duties toward man did not escape the earlier legislators, who severely punished their crimes and attempts upon human life. The law of Moses (Exodus xxi, 28, 29) recites: "If an ox gore a man or a woman, that they die: then the ox shall be surely stoned, and his flesh shall not be eaten; but the owner of the ox shall be quit. But if the ox were wont to push with his horn in time past, and it hath been testified to his owner, and he hath not kept him in, but that he hath killed a man or a woman; the ox shall be stoned, and his owner also shall be put to death."

Judgments based on this principle are recorded at Athens and Rome. According to Pierquin, Democritus wished an animal, which had occasioned some major damage, to be punished with death. Under Domitian, according to the report of Martial, the ingratitude of a lion toward its master was severely punished. Columella and Varro say that the ancient Romans regarded the ox as the companion of the labors of man, and that the act of killing one was regarded as a homicide and punished in the same way; and the ox enjoyed the same privilege in Attica and the Peloponnesus. It is also said that the Arabs in the mountains of Africa formerly crucified lions, guilty of murders, upon trees, as warnings to others.

In the middle ages they prosecuted animals which committed murder, those which had become dangerous to have at large, and females which, having given birth to monsters, were suspected of criminal cohabitations. Père Théophile Raynaud, Ayrault, Gaspard Bailly, and more recently M. Benoist Saint-Prix and M. Louandre ("Epopée des Animaux," "Revue des Deux Mondes," 1854), have cited some extremely curious examples of such condemnations.

In 1120 the Bishop of Laon issued a letter of excommunication against the caterpillars and the field-mice. Under Francis I an official advocate was provided for these animals, and pleadings were allowed between them and the farmers. In 1356, at Falaise, a sow having killed a child and begun to devour it, the judge condemned it to perish by the sword. As it had eaten an arm and part of the head of the child, one of its feet was cut off and its "face" was mutilated. Then it was dressed in man's clothes before being led to punishment, and the executioner received his customary fee of ten sous and a pair of gloves. In 1543 the consuls and aldermen of Grenoble published a decree demanding the excommunication of the snails and caterpillars. In 1585 the Grand Vicar of Valencia ordered the caterpillars, with which the country was infested, to evacuate his diocese. In 1587 an action was brought against the insects which were ravaging a field near Saint Jean de Maurienne, and they were condemned. Jean Milon, an officer of Troyes, pronounced the following sentence on the 9th of July, 1516: "Having heard the parties, and granting the request of the inhabitants of Villenove, we admonish the caterpillars to retire within six days; and, in case they do not comply, we pronounce them accursed and excommunicated."

M. Benoist Saint-Prix has collected eighty sentences of death and excommunications that were pronounced between 1120 and 1741 against every species of animals, from the ass to the grasshopper. He adds that, while in some countries animals have been employed as executioners, they have frequently been admitted in France as witnesses in suits. Who does not remember the history of the dog of Montargis, and the duel that Charles V ordered to be fought between the faithful animal of Aubrey of Montdidier and the assassin of his master, Richard Macaire?

The recital of these facts and a comparison of what has taken place in our time permit us to appreciate the great modifications that have been produced in the feelings of mankind. We have furthermore learned that, until our epoch, an erroneous idea prevailed regarding the offenses or crimes committed by animals. The actions of animals toward other animals had passed almost unperceived, and did not seem worthy of being noticed. It could not, therefore, enter the head of any person to investigate their moral bearing. The animal was adjudged and punished only when his offense bore upon man or society.

It appears to us that the time has come for a scientific study of certain criminal acts of animals, for the purpose of comparing them with similar acts committed by men and punishable by our laws. It is a study in comparative criminal psychology. We believe that such a work may have a higher bearing than that of a mere effort of scientific curiosity; and it seems to us, with Georges Leroy, that the moral condition of wolves may throw light upon that of men.

According to Georges Leroy, three motives influence the animal

and become the principles of his thoughts, his judgments, his determinations, and his actions. They are the seeking for food, the taking of precautions for his safety, and the gratification of his amorous desires. Leroy also suggests that we may recognize in beasts natural passions, and other passions which might be called factitious or reflexive. Of the former class are the impulses of hunger, the ardent desires of love, and maternal tenderness; of the latter are the fear of want, or avarice, and jealousy, which leads to vengeance. Other authors, among them Gall and August Comte, have endeavored to frame a classification of the cerebral faculties. Without discussing here these different systems which have been proposed chiefly to fix the number of man's elementary faculties, we believe that it will be convenient for the exposition of our subject to recognize among animals such instincts or elementary faculties as the nutritive, the genetic, the maternal, and the destructive instincts; and, as among those easier to establish with man than with animals, the instinct of vanity and the social instincts. We shall study particularly the exaggerations of these instincts, which are injurious to other animals of the same species, and which result in such specific acts as are regarded as crimes or offenses in human societies. "The animal and man," says Gall, "are organized for anger, hatred, sorrow, fear, and jealousy, because there are things and events which, according to their nature, deserve to be detested or loved, desired or feared."

1. Acts of Offense committed by Animals under the Influence of the Nutritive Instinct.—No distinctions are observed with regard to sex. When hunger makes itself felt, all animals exhibit, in different and varied degrees, according to their nature, the spectacle of the "struggle for existence." The fact is so well known that it does not require any great elaboration. The animals longest and most completely domesticated continue at feeding-time to steal food from each other, and to quarrel about it. The use of separate mangers, racks, boxes, and stalls, is based upon the knowledge of this fact. The object of the most important features of the interior arrangements of stables is to prevent the stealing of food and the trampling of the weaker by the stronger. It is well known that among the species which we see daily are individuals manifesting clearly the disposition to theft. Some of them have an exaggerated nutritive instinct, are avaricious, and lay up provisions. Leroy says that when wolves have brought down a large animal, they eat a part of it and carefully hide the rest; but this precaution does not abate their propensity to hunt, and they have recourse to their *cache* only when the chase has been unsuccessful. The same observation may be made with reference to dogs, foxes, and other animals.

M. Cornevin has remarked that, among species which live in community, not only is food stolen, but individuals which are on the point of perishing are eaten. Wolves, in spite of the proverb, rats and mice, eat

each other up. "Last year I observed several times among the Guinea-pigs, which were the subjects of my experiments, that those that died were eaten by the survivors. They were not troubled by hunger, for they had all the corn they wanted. Possibly they sought to appease their thirst in the blood of their victims." Büchner, in his psychical lives of beasts, speaks of thievish bees, "which, in order to lessen their labor or dispense with it wholly, made attacks in mass upon provisioned hives, committed violence against the sentinels and the inhabitants, pillaged the hive, and carried away all the store of honey. If this exploit was successful for several times, they, like men, acquired a stronger taste for pillage and violence than for work, and ended by constituting real colonies of brigands." There are isolated individuals which are addicted to theft, and endeavor to slip, without being perceived, into a strange hive; their sly tricks demonstrate that they are forced to concealment, and are conscious that they are transgressors. If they succeed in their attempt, they afterward bring other bees to their hive to tempt them to similar thefts, and thus form a society of thieves. Büchner adds that bees may be artificially made thieves by feeding them a special food consisting of honey mixed with brandy. "Like man, they readily acquire a taste for this beverage, which exercises the same pernicious influence upon them as upon him; they become excited, intoxicated, and cease to work. Do they feel hunger? Then, like man, they fall from one vice into another, and give themselves up unscrupulously to pillage and theft."

2. Acts of Offense committed by Animals under the Influence of the Genetic Instinct.—Such acts may be distinguished between those committed by the male and those committed by the female. The former are more frequent and violent than the latter. Some animals indicate a feeling of decorous modesty, while others are absolutely shameless. Without going into details on this subject, it may be considered sufficient here to remark that most of the sexual offenses which have been defined by the law or put under the ban of human societies may be observed among animals in their intercourse with each other; and instances are on record in ancient and modern history, though rare and not always well authenticated, of attempts by animals against human beings.

3. Acts of Offense committed by Animals under the Influence of Maternal Love.—The exceedingly marked development of this instinct in female animals well justifies the epithet maternal.

Gall has remarked that while the instinct for propagation is extremely ardent among the males of certain species—the cock, the dog, the boar, and the stag, for example—without the animals taking the slightest interest in the young, the instinct for propagation is also generally more active in the male than in the female, and generally, also, the female feels a stronger love for the offspring. Many animals,

as among the insects and amphibiæ, and the cuckoo, take no care at all of their young, although they mate ardently.

Other animals, as with ants and bees, do not exercise the act of propagation at all, yet they very assiduously take care of the eggs and larvæ. The same author insists upon individual differences, and cites cases, the counterparts of which would be called in human societies abandonment of children, abduction of minors, seduction, infanticide, etc.

Some cows, mares, and dogs bear the loss of their young with a degree of indifference; others even abandon them regularly. Pigeons generally, male as well as female, appear indifferent to their broods, while the rail and the corn-crake are so devoted to them that their heads are frequently cut off by the reaper's sickle. When a house in which storks have a nest takes fire, the father and the mother stork will fall into the flames rather than abandon their young. Boerhaave has made the same observation with respect to the chimney-swallow. The female partridge loves her own young with a strong affection, but she chases away and kills the young of other partridges. The pheasant, on the other hand, shows much less affection for her own young, and does not mind the loss of those which stray from her, while she receives joyfully and takes under her protection little pheasants that are strangers to her.

Gall tells of mares that have such a passion for colts that they kidnap the foals from other mares, and take care of them with a jealous fondness; and Espinas notices the same fact among asses. Pierquin had a dog of a Scotch breed, which was shy of the male, but would capture every puppy it met, and was in the habit of stealing out of the house to go hunting for them.

Among facts of an opposite character, we cite the case of a friend's dog which bore three or four litters, of which it would take proper care during the first three months, and would then carry them away into the mountain and leave them. We must also take notice of that inexplicable aberration that leads many females among our domestic animals to suffer their progeny to die, or kill them; while other animals, dogs, for example, become thieves during the whole time that they are taking care of their young. Females of the larger domestic species frequently refuse to let their young suck them, with the result that the young die. This is most remarked of animals bearing for the first time. The most astonishing fact is that of infanticide, which is almost the rule with certain species, notably with swine.

4. Acts of Offense committed by Animals under the Influence of the Destructive Instinct.—This instinct acts when animals are urged to overcome the obstacles that oppose the satisfaction of their desires. Thus they become murderous in time of heat; they seem to have gained new force; their nature has become irascible and furiously disposed; and contests of the most bloody character take

place between them. Pierquin adds that baffled love often leads man as well as animals into a murderous monomania. Buffon cites examples of animals which were frequently subject to a murderous passion. He speaks of canary-birds which were so wicked as to kill the female that was given them, and which could not be broken of the practice except by giving them two. Others are so barbarous in their inclinations as to break and eat the eggs as soon as they have been laid; and, even if the unnatural father allows the eggs to be sat upon, he will kill the young as soon as they are hatched. Pierquin mentions cross, quarrelsome dogs that are always ready to fight upon the smallest provocation. Wickedness of this kind may be manifested in certain races; it may be individual, permanent, and hereditary; or, while it is still individual, it may be accidental and transient, provoked by particular circumstances.

We may call a specific malignity that which one species shows toward another species that hunts it or is its rival in the struggle for existence. The instinctive repulsion of dogs and cats is proverbial. It is interesting, however, to observe how this repugnance can cease under certain conditions, as when the struggle for existence becomes less active. Commander Mouchez asserts that the cats and the rats on the Island of St. Paul, where he went to observe the transit of Venus, have ceased to war upon each other, and have instead joined in hunting birds. Cases of permanent and hereditary maliciousness are not rare. All who have had to do with domestic animals, says M. Cornevin, have observed that there appear among our subdued species, horses and cattle, individuals, both male and female, which are intractable, vicious, and absolutely useless; just as individuals of a similar character sometimes appear in human society. Such traits are often hereditary.

We have examples of the excitation of the destructive propensity by higher faculties in which malice seems to be consecutive to a real reasoning. First among them is the case of malice aroused by the recollection of bad treatment. Animals with such passion become murderers for revenge. They say that the mule always keeps a kick in store for the master who maltreats it; and examples are frequent of asses, mules, and horses, that were very gentle till they were chastised, remembering the blows they had received, and avenging themselves on the drivers who inflicted them. There are also murderers for rivalry. A bull that has been gentle enough as long as he has had his cows to himself will become vicious as soon as a rival is brought into the field, and will try to kill him or drive him away, and always keep watch over him.

M. Colin, in his treatise on the "Physiology of the Domestic Animals," cites two curious examples of criminality developed under the operation of the nutritive instinct. A dog at the school of Alfort, which was fed on the remains of dissected bodies, conceived a violent

and dangerous hatred for the skinner, who took away his meats. Another dog, which was fed together with a hog, took such aversion toward his commensal, that he broke his chain, jumped upon the porker, killed, disemboweled, and tore it.

Man has sometimes taken pains to develop the destructive instinct of animals. Jacolliot tells of elephants that were fed with meat to keep this faculty in a state of excitation. The Hottentots train cattle in a similar way. A legend runs to the effect that an exiled king of Garamanta returned to his country with an army of two hundred dogs. It is said, also, that when the Cimbri were defeated their dogs defended their chariots. The city of St. Malo is said to have been defended once in a similar manner; and during the night the animals were let loose in the streets as a kind of police. At the camp of Lobau, during the campaign in Italy, the soldiers trained large dogs to take prisoners. Watchmen in some prisons are accompanied in their night-rounds by dogs, to detect the prisoners who are out of their beds.

5. Acts of Offense committed by Animals under the Instinct of Vanity.—Though less susceptible than man, animals are very fond of praise and approbation. With what intoxication of joy does the dog receive our commendations! Every one has remarked how sensible horses are to marks of affection, and how they exert themselves in races so as not to allow a rival to pass them. Pierquin had a monkey which, when a handkerchief was given it, draped itself in it, and manifested an extraordinary pleasure in watching the train of its court-robe. Napoleon believed that man was only a more perfect animal, and claimed for his horse memory, intelligence, and love. "I had a horse," he said, "which could recognize me among all the world, and which showed, by his prancing and his proud step when I was on his back, that he knew he was carrying a person superior to all the others around him. He would not allow any one else to ride him except a groom who regularly took care of him, and his movements, when that man was upon him, were so peculiar that he seemed aware that he was carrying a servant." This was perhaps the same animal of which Constant wrote in his "Memoirs": "The Emperor had for several years an Arabian horse of rare instincts, that gave him much pleasure. It was hard to discover any grace in him while his master was out of sight, but whenever he heard the drums announcing the presence of his Majesty he would raise himself in pride, shake his head, paw the ground, and from that moment till the Emperor dismounted from him he would carry as fine a head as ever was seen." Such vanity is, in fact, quite common among Arabian horses, and the treatment they receive is well adapted to develop it. It is comprehensible that, under the influence of this instinct, and the jealousy that often results from it, animals may become malicious and quarrelsome, and attack and even kill their companions. It has been

remarked that these vain animals more readily attack ragged creatures, especially if they dwell where they are unaccustomed to the sight of misery.

6. Acts of Offense committed by Animals under the Influence of the Social Instincts.—Such social instincts as attachment and reverence can not be found among all animals. They evidently can not exist among animals which live isolated, or among those which mate only temporarily. It is otherwise, however, with those that live together, and between these a real marriage is established. So, when several couples or families have a common habitation, elevated social bonds are produced, quite comparable to those which are established in human societies. Examples will not be wanting, if we look at the bees and the ants, or at the republic of the rabbits. The idea of property, says Georges Leroy, certainly exists among rabbits; old age and fraternity are much respected by them.

Doves, turtle-doves, the roe, the chamois, and the mole can not support widowhood, and death generally follows the loss or absence of one of a pair of them. Some curious stories are told of the conjugal customs of storks. The males seem to be very jealous, and sometimes put to death an unfaithful companion and her betrayer. The inhabitants of Smyrna, who are well acquainted with the conjugal susceptibility of the male stork, amuse themselves by putting hens' eggs into the nests of these birds. The male becomes very angry at the sight of this unusual product, and, with the aid of other storks, tears his companion to pieces. There is certainly no need of calling up the numerous facts that show that domestication has, in certain animals, dogs, for example, developed these social instincts into a most touching devotion.

It seems to us that the review we have just made embraces a sufficiently large number of facts to permit us to establish an almost complete parallel between the criminal actions of men and those of animals. The analogy would have been closer if we had cited examples of tricks to show what combinations or means are at the disposition of an animal when it is seeking to accomplish its purposes. We can not, however, help remarking that there are authentic cases of simulation or deception which animals have worked out to save themselves from labor or to procure some advantage. A military surgeon tells of a horse which was accustomed to pretend to be lame on the days when the horses were drilled, in order to avoid that duty. Coste mentions a dog which, in the winter, when he found his comrades lying around the fire in such a way as to prevent his getting near to it, would make a great noise in the yard; at this the other dogs would run out, while he would slip into the house and, securing a good place for himself, leave his comrades to bark as long as they pleased. He tried this trick quite often, and always succeeded in it, for the other dogs had not intelligence enough to find it out.

With men, certain crimes tend to diminish or disappear under the influence of civilization. It is the same with animals. The more the domestication of a race is perfected, the less violent do its passions become, and, consequently, such crimes as we have discussed grow more rare. Not being troubled about their food, which is put before them in abundance and good order every day, they are not subject to the struggle for existence, and their character is mollified. Furthermore, by virtue of the law of organic balance, the development of the digestive apparatus, consequent on plentiful and regular feeding, takes place at the expense of the nervous system, whence less violence, less irritability, and less sexual passion. Malice is extremely rare among thorough-bred domestic animals, as, for instance, among the Durham cattle.

A man subject to relapses—this is his forty-fourth sentence—a man of quite solid education, yet who seems to pursue persistently the most absurd of evil schemes, wrote to me a little while ago: "I committed the first offense in my life, then repaired it. Repulsed everywhere and by every one, I pretended to steal, so that I could be arrested and condemned. All my condemnations have been for vagrancy or breaking my parole. I have always behaved well when I have had enough to eat. Misery makes a man wicked. With a piece of bread one may, perhaps, prevent a wretch from committing theft or murder." The criminal, says Hobbes, is a robust child; and Georges Leroy adds: "If we suppose a man to have strong desires, and to be without experience, like a child, it is hard to conceive of anything that will restrain him in the course he is pursuing. Our passions bring us back to childhood by vividly presenting to us a single object with the degree of intensity that eclipses everything else."

We believe that we have shown in this study that, if the acts, the thoughts, and the feelings of animals are similar to ours, the same is the case with their offenses and their crimes, so far as the same are related to their interests and their passions. As in our own species, the criminal animal is generally a type appearing sporadically, with passions, desires, and instincts that are not those of its race. These faults are transmissible and hereditary. Domestication and systematic feeding diminish, destroy, or transform these mischievous dispositions. We were right in saying, when we began, that the morals of wolves may throw light upon those of men.—*Revue Scientifique.*

SKETCH OF MATTHIAS JACOB SCHLEIDEN.

"TWO names," says M. Leo Herrera, in the "Revue Scientifique," "are inseparably connected with that grand movement of the biological sciences that began about 1838, and of which we to-day contemplate the superb bloom—Schleiden and Schwann. The two laid the foundations of the cellular theory. Both exercised a powerful influence over their contemporaries; both rendered lasting services to science through their teaching, their pupils, their ideas, and even through their errors."

Schleiden devoted himself variously to law, medicine, the natural sciences, and philosophy, and his works bear the marks of those diversified studies: but he was, above all, a botanist; it was under this title that he became famous, and by this his name must endure.

MATTHIAS JACOB SCHLEIDEN was the son of the physicist, Andreas Benedict Schleiden, and was born in Hamburg, April 5, 1804. On quitting the gymnasium he entered upon the study of the law at Heidelberg in 1824. He received his degree in 1827, and had entered upon the practice of his profession in his native city, when, in 1831, he concluded that the natural sciences were more to his taste than the law. With the encouragement of his father, he returned to the university, and studied medicine at Göttingen—where he enjoyed the instructions of Bartling in botany—and the natural sciences at Berlin, where his uncle, the botanist Horkel, enlisted his special interest in that branch. In 1839 he was appointed, on the recommendation of Humboldt it is said, Adjunct Professor of Botany at Jena, where he continued to teach in the chair of that science till 1862.

Schleiden was thirty-three years old when he published his first works; the scientific collections from 1837 to 1852 contain twenty-seven memoirs contributed by him. The most striking of these essays and the ones which contributed most directly to his rapid rise to eminence, were those in which he propounded his theories of the origin of plant-cells and of fructification. These were the "Beiträge zu Phytogenesis" ("Contributions to Phytogenesis," 1838), and "Ueber Bildung des Eichens und Entstehung des Embryos beim Phanerogamen" ("On Formation of the Ovule and Origin of the Embryo in Phanerogams," 1839)—his "most remarkable, most revolutionary, and most erroneous works," which astonished the world, "just as he had barely made himself known by a few anatomical and organogenical researches." Both of these works called forth lively responses. They were translated into English and French. They were commented upon and discussed, and were the subject of passionate debates; in short, inquiry was awakened, and an impulse was given to investigation, the force of which has not slackened to this day.

The theory of cells, as given in the "Phytogenesis," may be briefly stated as follows: There are two points in a plant well adapted for a ready and safe observation of the production of a new organization; these are the embryo-sac and end of the pollen-tube (according to his fertilization theory, the first cells of the embryo should form there, while in reality this is not the case). At both points, the formation of nuclei causes turbidity in the homogeneous gum-solution—these increase in size, and soon cytoblasts (a granular coagulation) appear. In the free state the cytoblasts increase rapidly until they attain a certain size, when they are surmounted by a fine diaphanous bubble; this is the young cell, at first a segment of a sphere, its plane side formed by cy. blasts, and its convex side by young cells (the cell-epidermis) similar to a watch-crystal on a watch. Gradually the bubble expands, becomes more consistent, and the wall is composed of cytoblasts and of a gelatinous substance. The cell grows, overlaps the cytoblasts, and then increases so rapidly that the cytoblast appears as a small nucleus inclosed in a duplicature of the cell-wall. As the growth progresses, the mutual pressure, exerted by the cells upon one another, causes a certain regularity of form, frequently that of the rhombendodecahedron. Only after the resorption of the cytoblasts the formation of secondary deposits begins on the inner surface of the cell-wall. Schleiden assumes the process thus described to be the general law of formation for the vegetable cell-tissues in the phanerogams. This theory was conceived while Schwann was still engaged with his theory of the origin and propagation of animal cells. Schwann has, in fact, acknowledged in his "Microscopic Researches" that Schleiden communicated his observations on the subject to him before publishing them, and thus gave him the light that showed him the way to his own results. So it has come to pass that, by means of the joint labors of these two men, the cell has been recognized as the peculiar element in both kingdoms of organic nature, and all the processes of vegetable and animal life have been located in its little laboratory.

Schleiden's theory has been proved to be a premature generalization, based upon incomplete and inaccurate observations, and has been refuted by Nägeli; but, incorrect and of little consequence as it was in itself, it has also proved to be the grain of ferment which has worked a transformation and revivification of biological science.

Schleiden's theory of fructification was announced just at the time (1839) when those who denied sexuality in plants had seemed to carry the day, and all botanists had agreed, to use the language of M. Herrera, in attributing the production of the embryo to the ovule, while allowing to the pollen only a simple action of fertilization. "All at once a botanist, already celebrated, proclaimed that he had seen the embryo forming in the grain of pollen and penetrating the ovule with the pollenical tube. This unexpected animalculist was Schleiden. His

animalculism was, however, limited to the vegetable kingdom. He did not aspire to extend it to the other kingdom. To explain the contradiction which thus appeared between the fecundation of animals and that of plants, he regarded the vegetable ovule as a male organ, and the grain of pollen, producer of the embryo, as a female organ. The announcement of this discovery came like a clap of thunder. It soon had enthusiastic partisans and angry critics. The critics were in the right, the partisans were at fault; but what does it matter now? Schleiden had again given a powerful impulse to the spirit of investigation, and that is the essential thing. His memoir, otherwise, is far from containing anything good or exact."

"Schleiden had disciples who were eager to adopt the doctrine of their master and promulgate it. At the same time, however, Mirbel and Brongniart skillfully guarded their opinions, and Meyen attempted a formal refutation of the new theory. A general and hot contest arose and lasted for more than twenty years, in which all the distinguished botanists of every country became engaged. Amici in 1842 confirmed and extended the previous observations of Mirbel, Spach, and Brongniart. He asserted that he had seen the embryo produced at the expense of a part of the embryonary sac, and this seemed to settle the question against Schleiden. Schleiden, however, hastened quickly to refute Amici's assertion. The great Modenese naturalist returned to the charge with his observations on the orchids. In 1850 the Academy of Amsterdam crowned a work of Schacht, a disciple of Schleiden's, who vigorously defended his master's theory. Tulasne, Hugo Mohl, Brongniart, Ch. Müller, and Hofmeister came forward to oppose it. It gave way and seemed to be dead; then it rose again and renewed the contest. On the 19th of December, 1854, Schacht triumphantly announced to the congress of naturalists, at Berlin, that a young man, Th. Deecke, a partisan, like himself, of Schleiden's doctrine, but more fortunate than he, had succeeded in making a microscopic preparation of *Pedicularis sylvatica* which was of such a nature as to reduce for ever to silence the adversaries of that theory. This preparation had a great repute. The story was passed around from city to city, but, while Schacht pretended that it was unanswerable, Hugo Mohl declared that he saw nothing conclusive in it. This was the last flickering of the theory of Schleiden. Radekofer published numerous observations against it in 1856, and announced at the same time that Schleiden had himself abandoned the theory which he had put forward. Shortly afterward, Schacht also acknowledged that he had been in error, and the theory, left dead on the battle-field, was buried for good."

With the vitality which Schleiden and his contemporaries had infused into botany a new era was inaugurated for the science. To mark its coming and extend the comprehension of the principles and aspirations of the new school, were needed a compendious and method-

ical treatise for students and a popular book for readers. Schleiden composed both. The time had passed when the study of living beings should form a separate branch of science, and when those who discarded the dry enumerations of the classifiers would have to fall into the ideal reveries of the "philosophers of nature." It needed to be shown that botany was not the mere dry skeleton which the former would make of it, and that it did not require the tinsel with which the latter assumed to adorn it. In the "Grundzüge der wissenschaftlichen Botanik" ("Elements of Scientific Botany") of Schleiden, the science was for the first time treated entirely according to the inductive method, as physics and chemistry had already been considered; and the different branches of science, till very recently still isolated and almost hostile, were made to interpenetrate and mutually illustrate each other. The book was well adapted to enlarge the scientific horizon, and to inspire youth and develop the spirit of research in them. The reading of the first few pages of the book is sufficient to give this impression of its motive. The dedication to Alexander von Humboldt, unquestionably the man of most universal knowledge of his time, attests the author's desire to connect botany intimately with the other sciences. The capital importance which he rightly attached to method is affirmed by the title which he gave to the second edition of his treatise—"Botany as an Inductive Science." The very first lines of his preface show that he does not intend to deal with a science of words and dreams, but of observation, experiment, and independent thought. "Whoever thinks he can learn botany in this book may as well put it aside at once without reading it, for botany can not be learned from books." In this work, says Dr. Karl Müller, Schleiden expressed for the first time a full comprehension that natural science was essentially a history of development, and expressed it in such a manner as to attract enthusiastic youth to his doctrine while he incurred the hostility of the elders in science. Among the salient features of his theory are the ascription of a leading part in all morphological questions to the study of the development of the organs, and his putting of the cryptogams upon a footing of equality in consideration with phanerogams. Perhaps no innovation in science has been so fruitful as the step which gave the prominent place in study to the first stages rather than to adult forms, to inferior beings rather than to elevated and complex groups.

One passage in the "Grundzüge" is worthy of especial remark, for the evidence it bears of the completeness of the author's rejection of the sterile categories of the older philosophers, and of his having been endowed with the scientific spirit of later times. "The division of natural objects into organic and inorganic could only have originated at a time when students had only the two extremes to consider. A person comparing a lion with a piece of chalk would, doubtless, say that the difference is evident to all the senses. But let him compare

the small, almost spherical crystals of oxide of iron with the minute, spherical articulations of Ehrenberg's *Gallionella ferruginea*, which likewise consist almost exclusively of oxide of iron, and undeniably represent organic forms, either animal or vegetable: the crude antithesis disappears at once, and all who reflect will conceive for science the possibility, still distant, of bringing the formation of both kinds under the same law of nature. There are in nature thousands of these apparent leaps, like that from the inorganic to the organism, in regard to which attentive observation will reveal to us gradual differences instead of a specific distinction."

This work excited a wide-spread and virulent opposition in consequence of the bitterness of its polemics, its severe criticisms of the didactic methods of investigation and the dry systems in vogue at the time, and its sharp personalities. The book was called libelous in France, for the author, according to Dr. Karl Müller, seemed to speak well of no one except Robert Brown and Hugh Mohl, "the two living men whom he most admired," and was not sparing in his criticisms of them. "With incomparable acuteness, and with equal acerbity against living and dead, he poured out such a flood of botanical satires and personal antipathies that he would have had to be a god to escape the reaction against his attacks; and the day when this was to take place was not long in coming." Yet, he did not let his vehement criticisms go forth without making an excuse for them. It was that "enough merit still exists among true naturalists to permit us to leave the business of mutual admiration to the literary beggars of *belles-lettres* journalism." Notwithstanding this opposition, the current in favor of Schleiden's conception of the object of scientific study could not be diverted; and the medical faculty of Tübingen, one of whose members was Schleiden's most eminent opponent in a number of special cases, replied to his acrid charges by conferring upon him its honorary degree.

Schleiden's other book, "Die Pflanze und ihr Leben" ("The Plant and its Life"), the object of which was to popularize botany, had a brilliant success. The first edition of 1848 was rapidly followed by other editions, and the work appeared in the course of the next ten years in one French, one Dutch, and two English translations. The author, in the preface to this work, defines his object as follows: "Most people of the world, even the most enlightened, are still in the habit of regarding the botanist as a dealer in barbarous Latin names, as a man who gathers flowers, names them, dries them, and wraps them in paper, and all of whose wisdom consists in determining and classifying this hay which he has collected with such great pains. This portrait of the botanist was, alas! recently true; but, now that it is no longer applicable to the majority among us, I have been grieved to see that many still hold to it. So I have endeavored in these lectures to place within the reach of all the real principles of botanical science, and to

show how it is intimately connected with all the leading problems of philosophy and the natural sciences." Beginning with an account of the structure of plants as revealed by the eye and the microscope, he recognizes the labors of Mohl, Nägeli, Payen, and others, and even has the courage to admit that they have damaged his own theory of the genesis of cells. The discussion of the nutritive elements of plants gives him occasion to do justice to Hales, De Saussure, Boussingault, and Liebig, his long-time adversary. Then, from applied botany, he passes to the two sciences which were quite new at the time, of botanical geography and paleontology ; and he concludes with a chapter in which the whole subject receives an æsthetical treatment.

Before this work appeared, however, Schleiden, discouraged by the success of the assaults upon his pet theories, had suffered a loss of confidence in himself and of relish for pure botany. His last work in pure science was a note on the fructification of the Rhizocarps, published in 1846 ; the "Zeitschrift für wissenschaftliche Botanik" ("Journal of Scientific Botany"), which he, with Nägeli, had founded in 1844, ceased to appear at the same time.

After completing the third edition of the "Grundzüge" in 1850, the failure to modify or improve which in any essential particular emphasizes his loss of relish for the pursuit, Schleiden withdrew almost entirely from the arena of scientific botany. He turned his attention to anthropology ; and, finally, in 1862, resigned his chair of botany at Jena, whence he repaired to Dresden. "Still, however, the old halo wavered around his head," and he was called to the University of Dorpat, as Professor of Botany and Anthropology, with the rank of a Russian councilor of state. He was not permitted to stay long there, however ; for, being accustomed to express himself too freely on ecclesiastical subjects in his public addresses, he soon raised a strong party against himself, and was obliged to resign his second professorship in 1864. From this time till the end of his life he resided by turns at Dresden, Frankfort-on-the-Main, Wiesbaden, and again at Frankfort, where he died on the 23d of June, 1881. Death surprised him while he was engaged upon a work on the horse, one of three monographs in which he designed to illustrate the influence of natural agents upon civilization, choosing as examples from each of the three kingdoms—salt, the rose, and the horse. The two of these treatises which we possess are models of their kind.

The character of Schleiden may be read in his writings. Ardent and enthusiastic, he never praised or blamed by halves ; but, in his most animated polemics, there appears a sincere and disinterested conviction that commands respect. To the end of his life he retained a degree of youthfulness in his thought and style. He had the imagination of a poet, with the scientific spirit to guide it ; and instead of being carried away, or letting his readers be carried away, in his flights, he is constantly calling them back to reality and reason. He

erred in that he relied too much on his own deductions, and did not sufficiently appreciate the importance of verifying them by experiment and close observation. Thus it came about, as Karl Müller has remarked, that he has given us, in his works, "a diversified mixture of philosophical prepossession, jejune observation, and fanciful description. Nevertheless, despite his peculiar weaknesses, his followers recognize him as a reformer of botany, and allot him a permanent and eminent place in the history of that science."

Schleiden's works are numerous; we will mention "Grundzüge der wissenschaftlichen Botanik" (two vols., Leipsic, 1842–'43) ("Elements of Scientific Botany"), fourth edition 1861, translated into English by Dr. Lankester, London, 1849; "Die Pflanz und ihr Leben" ("The Plant and its Life"), sixth edition, Leipsic, 1864, translated by Professor Henfrey, London, 1848; "Handbuch der medicinisch pharmaceutischen Botanik" ("Manual of Medicinal Pharmaceutical Botany"), (Leipsic, 1852); "Studien" ("Studies"), (second edition 1857); "Handbuch der botanischen Pharmakognosie" ("Manual of Botanical Pharmacology"), (Leipsic, 1857); "Die Landenge von Suez" ("The Isthmus of Suez"), (1858); "Zur Theorie des Erkennens durch den Gesichtssinn" ("Additions to the Theory of Determination by the Sense of Sight"), (Leipsic, 1861); "Geognostische Beschreibung des Saalthals bei Jena" ("Geognostic Description of the Valley of the Saal at Jena"), (Leipsic, 1846); "Beiträge zur Botanik" ("Additions to Botany); "Pflanzen und Thierphysiologie in Encyklopädie der theoretischen Naturwissenschaft" ("Physiology of Plants and Animals in Encyclopædia for Theoretical Natural Philosophy"), (Braunschweig, 1850); "Gedichte" (pseudonym "Ernst"), ("Poems") (*nom de plume* "Ernst"), 1858; "Das Meer" ("The Ocean"), (Berlin, 1865); "Baum und Wald" ("Tree and Forest"), (1870); "Uber den Materialismus der neueren deutschen Naturwissenschaft" ("Materialism in Modern German Natural Philosophy"); "Die Bedeutung der Juden für die Erhaltung und Wiederbelebung der Wissenschaften im Mittelalter" ("The Signification of the Jews in the Conservation and Revival of the Sciences in the Middle Ages")—a work demonstrating the high degree of culture maintained by the Jews, even during the darkest periods of history, and the important part they had in the development of science and letters in Christendom—(1877); "Die Romantik des Martyriums bei den Juden im Mittelalter" ("The Romance of the Jewish Martyrology of the Middle Ages"), (Leipsic, 1878).

ENTERTAINING VARIETIES.

—— *Hindoo Ascetics.*—Hindostan is the native land of religious fanaticism. Burke ascribes it to the impressive grandeur of Nature (Himalayas, great rivers, East Indian tornadoes, etc.); Jacquemont, to subjective peculiarities of the East Aryan races; but the fact itself admits of no dispute: the Hindoos, as a nation, have always shown a remarkable tendency to sacrifice reason to faith, earth to heaven, and the welfare of the body to the fancied interests of the soul. The cave-temples of Ellora are said to have been excavated by volunteer armies of laborers; and, in a country where large hospitals full of eupeptic monkeys can be supported by voluntary contributions, such things are by no means impossible. During the yearly assemblies on the "God-field," at the junction of the Jumna and Ganges, many devotees sought a grave in the depths of the twice-holy flood, and Father Ricot, who witnessed one of these festivals, ascribes the extravaganzas of the pilgrims to the momentary inspiration of religious frenzy; but the achievements of the fakirs prove that even the modern Hindoos are capable of the most deliberate self-sacrifice. At the court of Baroda the spectators often leave the circus-games of the Guicowar to witness the stranger performances of a self-torturer, who, "for the edification of the pious," skewers, scorches, or mutilates himself in a way from which no mortal could recover. Nepaul, the border-land of Buddhism and Brahmanism, swarms with fakirs as Spain with begging friars. On the highway from Goorkha to Benares the traveler meets them at every cross-road. Some of them content themselves with sitting bare-headed in the open sun; others hang, head downward, from a bar, which they clasp with their hands and knees; others exhibit self-inflicted wounds, gashed faces, bared and splintered ribs, hands and feet bristling with tenpenny nails, as if they had undergone crucifixion. In the larger cities, where the public is used to such trifles, the more ambitious ascetics load themselves with wagon-chains, or bend their bodies in the form of a right angle, till the inflection of the spine becomes permanent. Nay, a not unfrequent "penance" consists in tying the hands to the ankles, and turning round and round like a cart-wheel. Near Goruckpoor the train of Lord Dalhousie met dozens of these animated monocycles, some of whom had rolled along for a distance of several hundred miles!

The Buddhists, with their superior talent for organization, have whole convents full of martyr-maniacs, who vie in the rigor and extravagant absurdity of their penances. Even novices forswear clothes in winter and cold water in summer, and sleep on gravel-piles. The sanctity of the presbyters is computed by the quantity of nauseous drugs they can swallow. Some of them emulate Dr. Tanner, and eat only once a day, and at certain seasons only once a week. Near Rangoon, at the mouth of the Irrawaddy, a society of penitents have located their convent in a pestilential swamp, and point with pride to their open windows, that admit every variety of troublesome insects. A thousand miles farther north the Thibetan monastery of Sookung braves the ice-storms of the eastern Himalayas at an elevation of fourteen thousand five hundred feet. The monks subsist on the charitable contributions of the neighboring towns, and are often in danger of freezing to death before they reach their castle in the clouds; but their home-life is said to be comparatively comfortable, especially in winter-time, when visitors are rare, for asceticism of the more persistent kind seems somehow to

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depend a good deal on public approbation. Simon Stylites had visitors from all parts of the Christian world, who admired and at last almost worshiped him. Besides sticking to his pillar, he had a trick of doubling himself up till his forehead almost touched his narrow pedestal. At evening prayers he often treated the spectators to a variety of Talmagian gymnastics, and, if they implored him to come down, his only answer was a grunt of stern defiance. In a lonely desert he probably would have anticipated their wishes. If there is anything meritorious in self-torture, the Indian fakirs, too, get all the encouragement they deserve. A Hindoo, who might dismiss an ordinary beggar with a kick, would share his last rice-cake with a mendicant presenting himself with a drag-chain round his neck and a bull-ring in his nose. The inventor of a new torture can count upon a liberal share of public patronage. The English garrison of Cawnpoor was once honored by the presence of a *bikschu*, or religious devotee, who had stationed himself in a corner of their parade-ground, and promoted the welfare of his soul by squatting down between two blazing fires, while the sun inflicted its caloric on his shaven head. A crowd of natives watched him with respectful admiration, and, whenever one of his fires threatened to go out, they fetched in a fresh supply of fuel, to further the progress of the good work.

The exploits of a sensational *bikschu* become the boast of his native place. Rass-el-Shork and Rass-el-Hissam, two suburbs of Delhi, had several riots about the respective merits of their fakirs. The matter was finally referred to a Mohammedan umpire, and the men of Hissam proved that their hero had passed forty-eight hours in tenter-hooks, and glorified Brahma by eating a three-pound bundle of wormwood, while the Shork party claimed the prize of virtue for a saint who had swallowed a gallon of cajeput-oil, and turned somersaults till the arithmetic of the suburb failed to express the number of thousands. He had also rolled himself from Delhi to Agra, fasted a full week, and abstained from drinking water while he counted the number of grains in a two-bushel measure of millet-seeds. But all his labors proved in vain when the umpire learned that the Hissam champion had once sat two days and a night in a nest-hill of the *Formica rufa* (a kind of red horse-ants).

Our word *fakir* is derived from the Arabian *fakhar*, a pauper, a mendicant. The Mohammedan dervishes, however, do not entirely part with their reason, though the Sufi sect believes in the sanctifying influence of celibacy and solitude. The Brahmans and Buddhists are both ultra-ascetic, but with this difference: that the former practice their penances as an expiation of some special sin; the others on general principles, and with a view of subduing the vitality of the body, for the world-blighting dogma of the antagonism of body and soul seems to have been first promulgated by Buddha Sakya-Muni, the Nepaul arch-pessimist.

—— In the columns of the "Catholic World" for August, the Rev. J. F. Callahan, D. D., discusses the "Cincinnati Pastoral" and its critics: "Liberty," says the Rev. J. F. C., D. D., "never did exist except under the shadow of the cross. Equality has no home except at the altar on which the shadow of that cross falls. Take the Catholic Church out of the world, and liberty would sink into an eternal grave. If Protestant nations are free, it is because they once were Catholics. If a republic was built in this New World, Catholic principles were the architect."

The absolute truth of the above rivals the candor of Dr. Christlieb's "Short Method with Infidels." Evidently the "persecuted classes," as the "Bavarian Brewers' Union" calls the Romanists and liquor-dealers, are learning the art of

turning the tables against their aggressors. The next issue of the "B. B. U." will probably contain the following counterblast against the recent amendment of the Iowa Constitution: "Happiness never did exist except in an atmosphere of alcohol. Health has no home except at a fireside redolent with the smell of that atmosphere. Take distilleries out of the world, and manhood would sink into an eternal grave. Wherever a healthy constitution has been built up, alcoholic stimulants were the architect. If total abstainers are healthy, it is because their fathers were topers."

—— In "graphic descriptions" one touch of nature is worth a page of imaginary details: hence the realism of rustic poetry. The Ettrick Shepherd had passages of that sort that redeem all his barbarisms, and beat Goethe and Wordsworth at their own tricks. E. g., his description of a Lanarkshire snow-storm that cost the life of a Scotch Leander:

> "But the snaw was so deep, and his heart it grew weary,
> And he sank down to sleep on the moorland so dreary.
> Oh, soft was the couch and embroidered the cover,
> And white were the sheets she had spread for her lover;
> But his couch is more white, and his canopy grander,
> And sounder he sleeps *where the hill-foxes wander*."

—— "A false system with a fabulous historical record, and enforced by preposterously wrong methods," Diderot calls a certain anti-natural religion.

—— "Voltaire came before the Revolution like lightning before thunder."

"Experience is like a persistent coquette. Years pass before you can win her, and, if you finally may call her your own, you are both superannuated, and have no use for one another."

"The secret of every power consists in the knowledge that others are still greater cowards."

"Our time is not favorable to logic. So many candles need snuffing, that there is no chance for clear-seeing."

"All men love freedom. But the just demands it for all, the unjust for himself alone."—Ludwig Börne.

—— Some people seem born to be lucky in spite of themselves. General Skobeleff was originally destined for the bar, but before he was too old his pugnacious disposition caused his expulsion from college, and thus drove him into his right career, and by a series of equally well-timed scrapes at last into a field where he could follow his *penchant* with glory, as well as impunity. His pet project was a war against Prussia, and the timely accession of a Pan-Slavistic Czar enabled him to achieve popularity by a free expression of his anti-German sentiments. He became the idol of his nation, and died in time to escape the horrible thrashing that will follow the attempt to realize his favorite project.

—— There is nothing new under the sun; even our forestry associations had their prototypes in pagan Rome and Moorish Spain. Al Moctader, the Caliph of Bagdad (1094–1117), also planted millions of forest-trees; and it is a distressing fact that then, as now, many clear-sighted men foretold the consequences of reckless forest-destruction, and that their protests had no appreciable influence in checking the evil. The trouble seems to be that tree-felling is directly profitable and only eventually injurious, while tree-planting is directly expensive and only indirectly advantageous. Forest-destruction has ruined our earthly paradise, and the scientific authorities of all really enlightened nations have de-

nounced it again and again; but, before such arguments can influence the masses, they must cease to seek their paradise in the clouds and their authorities in Palestine.

—— In the general diffusion of knowledge, only the newspaper-educated natives of our Northeastern cities can compare with the Saracens of the thirteenth century. Under her last caliphs, Cordova alone had fourteen lyceums and nine hundred and fifty primary schools; the transcription of the ancient classics employed an army of copyists, and the provincial governors vied in patronizing men of letters. From Leon to Granada every hamlet had its own library, and the lord of every castle a private cabinet of *curios* or an astronomical observatory. But during the next two centuries a horde of ecclesiastic Vandals marched in the wake of the Christian armies, and special commissioners of the Casa Santa traveled from place to place, burning Unitarians and destroying Arabian manuscripts.

What literary treasures may have perished in that way! The Spanish Moriscoes, the last free and manly nation of the Old World, succumbed to the hirelings of the Holy Inquisition; but Providence generally remedies a calamity of that sort, and the fall of Granada coincided with the discovery of a New World.

—— *A Maori Cosmogony.*—Richard Oberländer, in his "Strange Peoples," gives the following as a cosmogony of the New-Zealanders: Maui was a hero who performed as wonderful labors as the Grecian Heracles. He was not only the inventor of the arts of making boats and building houses and the like, but he appointed the paths of the sun and the moon, and was the creator of the earth, which he fished out of the sea in this way: He said one day to his five brothers, who were devoted fishermen, that he would go with them and catch so large a fish that they would not be able to hold him. Now, because they knew what an enchanter he was, and were afraid of his art, they were not willing to take him in the boat with them. Nevertheless, Maui went with them. He changed himself into a bird, flew into the canoe, and did not make himself known till they had got into the open sea. When they had got far out into the sea, Maui wanted to fish; he had a precious fish-hook with him, which he had made out of his grandfather's jaw-bone; but his brothers, to keep him from fishing, refused to give him any bait. Then Maui beat his face till his nose bled, and soaked some tow that he found in the canoe with the blood. That was the bait. Maui threw out his hook, and it was not long before he had a bite, with a tug that made the brothers afraid the boat would be upset. So they cried out, "Let go, Maui!" "Maui never lets go of what he holds," was the answer, and it has become a proverb with the Maoris. He pulled and pulled at the line till he pulled up a land. "*Ranga whenna!*" exclaimed the brothers, "the fish is a land!" Maui asked them if they knew the name of the fish, and, when they said no, he told them "*Haha whenna*" (the looked-for land.) After the fish was pulled up, the brothers hastened to divide it among themselves; they pulled and tore in every direction; hence come the inequalities of the island. The canoe was stranded by the rising of the land, and the Maoris say now that it lies on the top of Mount Ikaurangi, near the eastern cape of the island, where Maui is also buried. After this story, the northern island of New Zealand is called *Ahi na Maui* (the fish of Maui).

—— "They sow not, they reap not, they trust in Providence, and honor you by sharing the fruits of your worldly industry," is the gist of St. Francis of Assisi's argument in favor of the mendicant friars. The Hindoos are consistent

enough to grant the same privileges to monkeys and crocodiles. In Lucknow there are two large monkey-hospitals, and several *mahakhunds*, where swarms of able-bodied Entellus-apes ("Honumans") and Rhesus baboons are fed at the expense of true believers. They get rice-pudding and sirup for dinner, while many hard-working but less sacred bipeds have to eat their rice "straight." But during the Sepoy rebellion the Mohammedan insurgents destroyed one of these establishments and expelled the inmates, including several venerable specimens of the white-headed Entellus, the holiest animal in the menagerie of the Hindoo Pantheon. For many weeks these long-tailed saints perambulated the streets in quest of cold lunch; and an eye-witness, Mrs. Allen Mackenzie, describes the indignation of the orthodox natives, who organized relief committees and monkey soup-houses, though the protracted siege had almost exhausted their own resources. To make matters worse, the streets swarmed with profane monkeys who had to forage for a living, and had no hesitation in black-mailing their sacred relatives. The Honumans had to submit to such outrages; nay, some of them learned to eat their rice-pudding without sirup, and probably consoled themselves with the hope of a better hereafter. They wandered from house to house, and in their great distress even accepted the assistance of unbelievers, but they absolutely refused to work.

—— *A Cheerful Summer Resort.*—On the hunting-grounds of the lower Lena, where the Fahrenheit thermometer often remains for weeks at 45° below zero, the Russian convicts are dressed in linen jackets, and wear *tretschki* (raw-hide shoes) without stockings. And yet they form the *élite* corps of the Siberian exiles—murderers, forgers, and highway robbers. Political offenders are sent to the mines of Berezov, where the average duration of life, or rather of slow death, is eight years and four months. The majority of the convicts die in less than five years. Minors work there from 6 A. M. till noon, and from 2 to 6 P. M.; adults from 6 A. M. to 6 P. M., *without intermission*. They have no Sunday, and only one holiday in the year, the birthday of the Czar. Their rations are those of a private soldier, viz., rye-bread and salt beef. After dark they are confined in log-pens, and have to pass the nights of the long Siberian winter between two army-blankets, the one covering the rough-hewed logs of the floor, the other their starved bodies, wrapped in the coarse linen uniform which they are permitted to change only once a month. Chimney-fires are allowed during the supper-hour, i. e., from 6 to 7 P. M., but the majority swallow their food in the dark, and devote the short interval of light and warmth to—entomological researches. The discipline is that of a dog-kennel—kicks and cudgel-blows—and malingering is discouraged by a simple and effective method: the sick (wounded excepted) are put on quarter-rations. Attempts at flight are less frequent than riots, for recaptured fugitives were knouted; mutineers are only shot.

Human beings can get used to worse things than Siberian rye-bread, but never to Siberian frosts, and the monthly fuel rations of the Berezov convicts are limited to one *stavenik* (about half a cord) per cabin, though near the mines of the western slope the same mountain-range abounds with densely timbered districts. In an interview with the commander of Berezov, a correspondent of the "Cologne Gazette" suggested the propriety of removing the settlement to the timber-region. "It would probably please the prisoners," replied the commander, but the comfort of their keepers was of more consequence, and all his subalterns agreed that, on account of the trout-streams and cranberry-brakes of the eastern slope, Berezov was a more pleasant summer resort.

EDITOR'S TABLE.

SPENCER'S IMPRESSIONS OF AMERICA.

THERE was a strong and perhaps a quite laudable curiosity on the part of many pople to know what impression had been made upon the mind of Herbert Spencer when first coming to this country. It was certainly something more than an idle curiosity on the part of a large number of our citizens to learn his impressions, because it was widely kown that he is a philosophical student of national institutions, and probably the highest living authority on the science of human society. He has been very widely read and much studied in this country, and it was felt that his views, whether favorable or not, would certainly be interesting, and his criticisms, if he made any, suggestive and valuable.

And it was no doubt because of his respect for this sincere desire, to get at his real views, that Mr. Spencer persistently declined to be hastily and prematurely interviewed by the professionals of the press, whose ways of doing such things are not always favorable to the representation of important truths. What they generally most want is frivolous gossip and personal particulars, to be dressed up for sensational purposes, and to be had exclusively for the benefit of enterprising newspapers. Mr. Spencer was indeed repeatedly applied to by reporters of a better character who would have represented him in his own way, and with fullness and fairness, but the state of his health long made it impossible that he could consent to be questioned.

And there was certainly plenty of reason why he should be in no hurry to venture upon an expression of opinion regarding American social and political affairs. It was easy enough to say how he was struck by the external aspects of American life, but it was not so easy to get familiar with the working of the internal elements and forces of our social and political life. It was easy enough to compare our cities, steamboats, railroads, rural scenery, and open habits of the people with those of the olden countries, but a very different thing to form an intelligent judgment of the operation of complex institutions and the slow-working social tendencies in a nation that covers a continent. Perhaps no living man is so well aware of the magnitude and the difficulties of the problems now being worked out by the people of these associated States as Mr. Spencer, and he could not but feel that a two months' sojourn among us in a very unfavorable state of health was but a very insufficient preparation for an intelligent verdict upon American social and political problems. Yet his previous occupation with such subjects certainly qualified him to form opinions of what he saw and heard and at the proper time he had no hesitation in expressing them.

And that he was prepared to speak a good deal to the point, to offer views of moment, and suggest weighty criticisms, has been sufficiently proved by the way his opinions have been received in all quarters. They have been very extensively published from the Atlantic to the Pacific, and as extensively commented upon. No such message from any foreigner has ever compelled equal attention, or been received in a better spirit. There has been very wide agreement with Mr. Spencer's most important statements, and, where assent has been denied, it has still been recognized that the questions raised are fundamental, and that Mr. Spencer has done us an eminent service in setting people to thinking about the sources of danger to

our institutions, and the duties of citizens in regard to them.

In one respect the time of publication was somewhat unfortunate. The results of the interview were offered to the New York press to all the New York newspapers at the same time and without previous notice, and, as the columns of the press are generally much crowded in an active political campaign, there was some difficulty in publishing the communication. Several papers felt it necessary to shorten it by omitting what they regarded as the less important parts, so that imperfect representations of the interview were extensively circulated and republished. This being known, there has been a good deal of call for the document in its complete form, which could not be met. We have accordingly thought it best to reprint the interview in full. It will certainly not be news to our readers, but it may be well to have a permanent record of it for future reference:

Hearing that HERBERT SPENCER had returned to New York in a somewhat improved condition of health, an intimate American friend obtained his consent to be questioned regarding his impressions of this country to the following effect:

I believe, Mr. Spencer, that you have not been interviewed since your arrival in this country?

I have not. The statements in the newspapers implying personal intercourse are unauthorized, and many of them incorrect. It was said, for example, that I was ill from the effects of the voyage; the truth being that I suffered no inconvenience whatever, save that arising from disturbed rest. Subsequent accounts of me in respect of disorders, diet, dress, habits, etc., have been equally wide of the mark.

Have these misrepresentations been annoying to you?

In some measure, though I am not very sensitive; but I have been chiefly annoyed by statements which affect, not myself only, but others. For some ten days or more there went on reappearing in various journals, an alleged opinion of mine concerning Mr. Oscar Wilde. The statement that I had uttered it was absolutely baseless. I have expressed no opinion whatever concerning Mr. Oscar Wilde. Naturally, those who put in circulation fictions of this kind, may be expected to mix much fiction with what fact they report.

Might not this misrepresentation have been avoided by admitting interviewers?

Possibly; but, in the first place, I have not been sufficiently well; and, in the second place, I am averse to the system. To have to submit to cross-examination, under penalty of having ill-natured things said if one refuses, is an invasion of personal liberty which I dislike. Moreover, there is implied what seems to me an undue love of personalities. Your journals recall a witticism of the poet Heine, who said that "when a woman writes a novel, she has one eye on the paper and the other on some man—except the Countess Hahn-hahn, who has only one eye." In like manner, it seems to me that in the political discussions that fill your papers, everything is treated in connection with the doings of individuals—some candidate for office, or some "boss" or wire-puller. I think it not improbable that this appetite for personalities, among other evils, generates this recklessness of statement. The appetite must be ministered to; and in the eagerness to satisfy its cravings, there comes less and less care respecting the correctness of what is said.

Has what you have seen answered your expectations?

It has far exceeded them. Such books about America as I had looked into, had given me no adequate idea of the immense developments of material civilization which I have everywhere found. The extent, wealth, and magnificence of your cities, and especially the splendor of New York, have altogether astonished me. Though I have not visited the wonder of the West, Chicago, yet some of your minor modern places, such as Cleveland, have sufficiently amazed me, by the marvelous results of one generation's activity. Occasionally, when I have been in places of some ten thousand inhabitants, where the telephone is in general use, I have felt somewhat ashamed of our

own unenterprising towns; many of which, of fifty thousand inhabitants and more, make no use of it.

I suppose you recognize in these results the great benefit of free institutions?

Ah, now comes one of the inconveniences of interviewing. I have been in the country less than two months; have seen but a relatively small part of it, and but comparatively few people; and yet you wish from me a definite opinion on a difficult question.

Perhaps you will answer, subject to the qualification that you are but giving your first impressions?

Well, with that understanding, I may reply that, though free institutions have been partly the cause, I think they have not been the chief cause. In the first place, the American people have come into possession of an unparalleled fortune—the mineral wealth, and the vast tracts of virgin soil producing abundantly with small cost of culture. Manifestly that alone goes a long way toward producing this enormous prosperity. Then they have profited by inheriting all the arts, appliances, methods, developed by older societies, while leaving behind the obstructions existing in them. They have been able to pick and choose from the products of all past experience; appropriating the good and rejecting the bad. Then, besides these favors of fortune, there are factors proper to themselves. I perceive in American faces generally, a great amount of determination—a kind of "do or die" expression; and this trait of character, joined with a power of work exceeding that of any other people, of course produces an unparalleled rapidity of progress. Once more, there is the inventiveness, which, stimulated by the need for economizing labor, has been so wisely fostered. Among us in England, there are many foolish people who, while thinking that a man who toils with his hands has an equitable claim to the product, and, if he has special skill, may rightly have the advantage of it, also hold that if a man toils with his brain, perhaps for years, and, uniting genius with perseverance, evolves some valuable invention, the public may rightly claim the benefit. The Americans have been more far-seeing. The enormous museum of patents which I saw at Washington, is significant of the attention paid to inventors' claims; and the nation profits immensely from having, in this direction (though not in all others), recognized property in mental products. Beyond question, in respect of mechanical appliances, the Americans are ahead of all nations. If, along with your material progress, there went equal progress of a higher kind, there would remain nothing to be wished.

That is an ambiguous qualification. What do you mean by it?

You will understand when I tell you what I was thinking of the other day. After pondering over what I have seen of your vast manufacturing and trading establishments, the rush of traffic in your street-cars and elevated railways, your gigantic hotels and Fifth Avenue palaces, I was suddenly reminded of the Italian republics of the middle ages; and recalled the fact that, while there was growing up in them great commercial activity, a development of the arts which made them the envy of Europe, and a building of princely mansions which continue to be the admiration of travelers, their people were gradually losing their freedom.

Do you mean this as a suggestion that we are doing the like?

It seems to me that you are. You retain the forms of freedom, but, so far as I can gather, there has been a considerable loss of the substance. It is true that those who rule you do not do it by means of retainers armed with swords; but they do it through regiments of men armed with voting-papers, who obey the word of command as loyally as did the dependants of the old feudal nobles, and who thus enable their leaders to override the general will and make the community submit to their exactions as effectually as their prototypes of old. It is doubtless true that each of your citizens votes for the candidate he chooses for this or that office, from President downward, but his hand is guided by a power behind, which leaves him scarcely any choice. "Use your political power as we tell you, or else throw it away," is the alternative offered to the citizen. The political machinery as it is now worked has

little resemblance to that contemplated at the outset of your political life. Manifestly, those who framed your constitution never dreamed that twenty thousand citizens would go to the poll led by a "boss." America exemplifies, at the other end of the social scale, a change analogous to that which has taken place under sundry despotisms. You know that in Japan, before the recent revolution, the divine ruler, the Mikado, nominally supreme, was practically a puppet in the hands of his chief minister, the Shogun. Here it seems to me that the "sovereign people" is fast becoming a puppet which moves and speaks as wire-pullers determine.

Then you think that republican institutions are a failure?

By no means! I imply no such conclusion. Thirty years ago, when often discussing politics with an English friend, and defending republican institutions, as I always have done and do still; and when he urged against me the ill-working of such institutions over here; I habitually replied that the Americans got their form of government by a happy accident, not by normal progress, and that they would have to go back before they could go forward. What has since happened seems to me to have justified that view; and what I see now confirms me in it. America is showing on a larger scale than ever before, that "paper constitutions" will not work as they are intended to work. The truth, first recognized by Mackintosh, that "constitutions are not made, but grow," which is part of the larger truth that societies throughout their whole organizations are not made but grow, at once, when accepted, disposes of the notion that you can work, as you hope, any artificially-devised system of government. It becomes an inference that if your political structure has been manufactured, and not grown, it will forthwith begin to grow into something different from that intended—something in harmony with the natures of citizens and the conditions under which the society exists. And it evidently has been so with you. Within the forms of your constitution there has grown up this organization of professional politicians, altogether uncontemplated at the outset, which has become in large measure the ruling power.

But will not education and the diffusion of political knowledge fit men for free institutions?

No. It is essentially a question of character, and only in a secondary degree a question of knowledge. But for the universal delusion about education as a panacea for political evils, this would have been made sufficiently clear by the evidence daily disclosed in your papers. Are not the men who officer and control your Federal, State, and municipal organizations—who manipulate your caucuses and conventions, and run your partisan campaigns—all educated men? and has their education prevented them from engaging in, or permitting, or condoning, the briberies, lobbyings, and other corrupt methods which vitiate the actions of your administrations? Perhaps party newspapers exaggerate these things; but what am I to make of the testimony of your civil-service reformers—men of all parties? If I understand the matter aright, they are attacking, as vicious and dangerous, a system which has grown up under the natural spontaneous working of your free institutions—are exposing vices which education has proved powerless to prevent.

Of course, ambitious and unscrupulous men will secure the offices, and education will aid them in their selfish purposes; but would not those purposes be thwarted, and better government secured, by raising the standard of knowledge among the people at large?

Very little. The current theory is that if the young are taught what is right, and the reasons why it is right, they will do what is right when they grow up. But, considering what religious teachers have been doing these two thousand years, it seems to me that all history is against the conclusion, as much as is the conduct of these well-educated citizens I have referred to; and I do not see why you expect better results among the masses. Personal interests will sway the men in the ranks as they sway the men above them; and the education which fails to make the last consult public good rather than private good, will fail to make the first do it. The benefits of political purity are so general and remote, and the profit to each individual so incon-

spicuous, that the common citizen, educate him as you like, will habitually occupy himself with his personal affairs, and hold it not worth his while to fight against each abuse as soon as it appears. Not lack of information, but lack of certain moral sentiments, is the root of the evil.

You mean that people have not a sufficient sense of public duty?

Well, that is one way of putting it; but there is a more specific way. Probably it will surprise you if I say that the American has not, I think, a sufficiently quick sense of his own claims, and at the same time, as a necessary consequence, not a sufficiently quick sense of the claims of others—for the two traits are organically related. I observe that you tolerate various small interferences and dictations which Englishmen are prone to resist. I am told that the English are remarked on for their tendency to grumble in such cases; and I have no doubt it is true.

Do you think it worth while for people to make themselves disagreeable by resenting every trifling aggression? We Americans think it involves too much loss of time and temper, and doesn't pay.

Exactly. That is what I mean by character. It is this easy-going readiness to permit small trespasses because it would be troublesome or profitless or unpopular to oppose, which leads to the habit of acquiescence in wrong, and the decay of free institutions. Free institutions can be maintained only by citizens each of whom is instant to oppose every illegitimate act, every assumption of supremacy, every official excess of power, however trivial it may seem. As Hamlet says, there is such a thing as greatly to find quarrel in a straw, where that straw implies a principle. If, as you say of the American, he pauses to consider whether he can afford the time and trouble—"whether it will pay"—corruption is sure to creep in. All these lapses from higher to lower forms begin in trifling ways; and it is only by incessant watchfulness that they can be prevented. As one of your early statesmen said, "The price of liberty is eternal vigilance." But it is far less against foreign aggressions upon national liberty, that this vigilance is required, than against the insidious growth of domestic interferences with personal liberty. In some private administrations which I have been concerned with, I have often insisted, much to the disgust of officials, that instead of assuming, as people usually do, that things are going right until it is proved that they are going wrong, the proper course is to assume that they are going wrong until it is proved that they are going right. You will find, continually, that private corporations, such as joint-stock banking companies, come to grief from not acting upon this principle. And what holds of these small and simple private administrations, holds still more of the great and complex public administrations. People are taught, and, I suppose, believe, that "the heart of man is deceitful above all things and desperately wicked"; and yet, strangely enough, believing this, they place implicit trust in those they appoint to this or that function. I do not think so ill of human nature; but, on the other hand, I do not think so well of human nature as to believe it will do without being watched.

You hinted that while Americans do not assert their own individualities sufficiently in small matters, they, reciprocally, do not sufficiently respect the individualities of others.

Did I? Here, then, comes another of the inconveniences of interviewing. I should have kept this opinion to myself if you had asked me no questions; and now I must either say what I do not think, which I can not, or I must refuse to answer, which perhaps will be taken to mean more than I intend, or I must specify, at the risk of giving offense. As the least evil I suppose I must do the last. The trait I refer to comes out in various ways, small and great. It is shown by the disrespectful manner in which individuals are dealt with in your journals—the placarding of public men in sensational headings, the dragging of private people and their affairs into print. There seems to be a notion that the public have a right to intrude on private life as far as they like; and this I take to be a kind of moral trespassing. It is true that during the last few years we have been discredited in London by certain weekly papers which do the like (except in the typographical display); but in our daily press, metropolitan and pro-

vincial, there is nothing of the kind. Then, in a larger way, the trait is seen in this damaging of private property by your elevated railways without making compensation; and it is again seen in the doings of railway governments, not only when overriding the rights of shareholders, but in dominating over courts of justice and State governments. The fact is, that free institutions can be properly worked only by men each of whom is jealous of his own rights, and also sympathetically jealous of the rights of others—will neither himself aggress on his neighbors, in small things or great, nor tolerate aggression on them by others. The republican form of government is the highest form of government; but because of this it requires the highest type of human nature—a type nowhere at present existing. We have not grown up to it, nor have you.

But we thought, Mr. Spencer, you were in favor of free government in the sense of relaxed restraints, and letting men and things very much alone—or what is called *laissez faire?*

That is a persistent misunderstanding of my opponents. Everywhere, along with the reprobation of government-intrusion into various spheres where private activities should be left to themselves, I have contended that in its special sphere, the maintenance of equitable relations among citizens, governmental action should be extended and elaborated.

To return to your various criticisms, must I then understand that you think unfavorably of our future?

No one can form anything more than vague and general conclusions respecting your future. The factors are too numerous, too vast, too far beyond measure in their quantities and intensities. The world has never before seen social phenomena at all comparable with those presented in the United States. A society spreading over enormous tracts while still preserving its political continuity, is a new thing. This progressive incorporation of vast bodies of immigrants of various bloods has never occurred on such a scale before. Large empires composed of different peoples, have, in previous cases, been formed by conquest and annexation. Then your immense plexus of railways and telegraphs tends to consolidate this vast aggregate of States in a way that no such aggregate has ever before been consolidated. And there are many minor co-operating causes unlike those hitherto known. No one can say how it is all going to work out. That there will come hereafter troubles of various kinds, and very grave ones, seems highly probable; but all nations have had, and will have, their troubles. Already you have triumphed over one great trouble, and may reasonably hope to triumph over others. It may, I think, be reasonably held that both because of its size and the heterogeneity of its components, the American nation will be a long time in evolving its ultimate form; but that its ultimate form will be high. One great result is, I think, tolerably clear. From biological truths it is to be inferred that the eventual mixture of the allied varieties of the Aryan race forming the population, will produce a more powerful type of man than has hitherto existed, and a type of man more plastic, more adaptable, more capable of undergoing the modifications needful for complete social life. I think that whatever difficulties they may have to surmount, and whatever tribulations they may have to pass through, the Americans may reasonably look forward to a time when they will have produced a civilization grander than any the world has known.

PRINCIPLE IN SMALL THINGS.

No part of the foregoing deliverance is more true than that which refers to American tolerance of interference and dictation in the lesser affairs of life. What people do, habitually illustrates character, and American character in this important respect is undoubtedly of a low type. The forms of free institutions have not engendered the sentiment of personal independence which resents encroachments and insists upon justice. The institutions are nominally free, but the citizens who grow up under them are not free in the sense of exemption from impertinent meddlings and petty tyranny.

There is wanting the spirit of resistance to apparently trivial violations of right. The man who would fight for his country will not fight a despotic neighbor, but will tamely acquiesce in wrong for the sake of peace and neighborly harmony. This spirit of complacent acquiescence in wrongs inevitably breeds wrong-doers to take advantage of it. Where there is a low regard for the strictly equitable, equity is sure to be violated. There are always natures that will encroach if not resisted, because the roots of aggression run deep in the soil of selfishness. Boys of strong wills that are petted and pampered, or left unrestrained at home, become bullies in the streets and tyrants in their social relations. "Resistance to tyrants is obedience to God," of course, but that means the *foreign* tyrant, not the one next door, or in the school-board, or church, or in the car, or restaurant — to resist him might make unpleasant disturbance. Habitual submission to inflicted wrongs, however small, is simply moral cowardice, and there is no disguising the fact that it is a very large element of the American character. Mr. Spencer has diagnosed our condition in this respect from a very few symptoms, but the illustrations of wrong tolerated from timidity and dread of what people will say, if small aggressions are seriously resisted, are all too plentiful. An excellent example of it occurred recently, which it is worth while to note.

Bicycles upon the sidewalks, as everybody knows, are not particularly conducive to the comfort of pedestrians. Even the small machines impelled by children, though hardly dangerous, are often annoying. But large bicycles, ridden rapidly by strong boys on the sidewalk, are sources of constant solicitude to those who are walking, are dangerous, often result in accidents, and are simply nuisances that should not be tolerated. In most English villages, as we are informed, bicycles are not allowed on the sidewalks; and the hand-books issued by English manufacturers of bicycles caution their customers that it is a forbidden practice, while in many places bells have to be attached to the bicycles even when ridden in the streets. To what degree this practice is general here in country towns we do not know, but there has recently been an experience in this matter in the village of Stockbridge, Massachusetts, which is quite American in its way.

In the first place, Stockbridge is a charming town among the Berkshire hills, much resorted to as a summer residence by city people. Moreover, the people that go there and the people that live there are eminently cultivated and refined; wealth abounds, and it is not a place where poor people are much harbored. In education, intelligence, and all the moral qualities which are said to accompany mental cultivation, Stockbridge is an American village of a superior sort. It will be long, very long before American villages generally come up to the Stockbridge standard of culture and good-breeding.

Nevertheless, all grades of bicycles were allowed upon the Stockbridge sidewalks, and the vexation and danger attending the practice were such, that last July one of the summer residents presented a petition, signed by eighteen prominent residents, to the board of selectmen, praying that the use of bicycles on the sidewalks be prohibited. Immediately after a remonstrance signed by thirty residents was got up and handed to the selectmen. Understanding that the main objection to the original petition was that it did not discriminate between large and small bicycles, the gentlemen who drew the first document prepared a second draft, asking only that *large* bicycles should be excluded from the sidewalks of the village, and this was signed by one hundred and sixty-eight residents.

Many who had signed the remonstrance now signed the petition, so that the consent of the village to the measure proposed was regarded as practically unanimous.

But there was an active party in favor of the boys, who were determined that they should not be interfered with in their amusement, and so the selectmen played into the hands of this party by excluding all bicycles, *large and small*, from the sidewalks, well knowing that this step would cause such irritation as to defeat itself. The consequence was that the order of exclusion was rescinded, and all bicycles, large and small, were once more allowed to run freely on the sidewalks, except in the small portion of the village occupied by the stores, hotel, and bank.

The gentleman, a distinguished professor of Columbia College, who moved in the matter, attempted to arouse public sentiment upon the subject, and, as there was no newspaper printed in the village, he posted up a handbill with a list of thirteen accidents, and cases of serious annoyance, that had occurred; and shortly after posted up ten additional cases, signed with his well-known initials, to show by facts that the practice resisted was really a dangerous one. These posters were removed by the selectmen. He then printed a letter, stating the case fully, and giving an account of twenty accidents, and placed a copy in every box in the village post-office, addressed to the chief residents. One was also sent to the editor of the "Springfield Republican," who made a notice of it, and one hundred copies of his paper were distributed in the village, all of which failed to produce any effect.

Now, our interest in this matter is purely scientific. We take the data, find their explanation, and draw conclusions respecting the true grade of Stockbridge society.

The facts in a sentence are simply these: Half a dozen boys, in the pursuit of a selfish gratification, persist in violating the rights of citizens, and this conduct is sustained by the community which yet acknowledges the outrage.

And how is it to be explained? By the indifference of the people to the subject as a matter of right and wrong; or a laxity of moral sense. The gentleman who moved in the matter, and should have been regarded as a public benefactor, was not supported, but was condemned for his action. Of course, when such an issue was once raised, there was tenfold necessity to put down the openly immoral party; but the raising of the issue only cowed their opponents, and disclosed the absence of moral backbone in the Stockbridge character. "It was really such a petty matter, such small business, to be meddling with the enjoyments of the dear boys!"—from which we get an idea of the quality of Stockbridge ethics, which is far too much the American sort. Small trespasses are to be tolerated, and only outrages that comport with the scale of American ideas are to be reprobated. Abuses that have in them something of the breadth of the continent or the length of the Mississippi, or the bigness of the national debt, are worthy to excite indignation; but mere sidewalk offenses—nonsense!

It is to be presumed, of course, that Stockbridge education conforms to the standard of its public opinion. The boys are sent to school, and taught book-lessons in morality, including sensitiveness to the rightful claims of others, and especially solicitude for the weak and helpless, and then they take lessons in the out-of-door practical morality of running over baby-carriages, upsetting old people, and disturbing everybody, because the sidewalk is a little nicer than the street for bicycle riding.

From all of which we may fairly infer the grade of Stockbridge civilization. Its people may be refined and educated, affluent, polished, and devo-

tional; but they are, nevertheless, barbarians: for the degree of barbarism in any community is measured by the impunity with which its members seek their gratification at each other's expense.

LITERARY NOTICES.

GEORGE RIPLEY. By OCTAVIUS BROOKS FROTHINGHAM. Boston: Houghton, Mifflin & Co. Pp. 321. Price, $1.50.

MR. FROTHINGHAM'S life of Ripley is a very pleasant and entertaining, if not in the highest degree instructive, book upon its subject. As a biographer, in this case he has the advantage of having been long and intimately acquainted with the man whose life he delineates, of having a similar culture and a broad sympathy with his aims. But while these qualifications are favorable to the appreciation of Mr. Ripley's character, they are not so favorable to that criticism of it which is perhaps necessary to extract the highest lesson from its career. Mr. Frothingham has given us a model biography from a literary point of view, but we suspect that in future the work of describing men's lives must more and more pass into the hands of those who have a scientific preparation for the work. We must have something more than the mere narration of a career in a fine literary form; we must have analysis and a critical judgment of character in relation to the circumstances in which it was displayed.

Mr. Ripley's life was divided into several stages. He was a bright, clear-headed boy of unusual capacity, fond of books, and learning from them with great facility. He accepted the customary course of study, and went through college early and with distinction. He was absorbed in classical studies, and paid very little attention to science of any kind. His culture was therefore one-sided, and he was in consequence to no small degree the victim to his university education.

From college he passed into professional life, taking the line of divinity. In preparation for this he had crammed German metaphysics to an inordinate degree, and brought a large theological erudition to his pulpit labors. He worked zealously and most conscientiously in this field for upward of a dozen years, and, being dissatisfied with the result, decided to abandon it. We are of opinion that with his strong common sense, if he had any fair share of scientific cultivation, he would either have kept out of the clerical profession or would have succeeded in it by subordinating theology to truth and making an independent career. He had abundant talent for this purpose. But, as it was, his theology broke down and he left it.

Mr. Ripley then entered upon the third stage of his career, which was both very natural and not a little remarkable. Earnestly desiring to realize a nobler ideal of life than is fulfilled by the present state of society, even under a religious organization which he had faithfully tried, he resolved to embark in a new social project that promised to yield higher satisfactions than are derived from the existing state of society.

He joined the association at Brook Farm, now a curiosity of history, and resolved to devote himself to the practical realization of a more harmonious social life by an experimental trial of what is possible in this direction. He had eminent coadjutors, who were animated by the same high aspirations, but Ripley was the life and soul of the movement. Never, perhaps, was before gathered a more sincere and unselfish band of devotees than those who made the attempt to carry out a reconstructive social reform at Brook Farm. The experiment failed, of course, and Ripley was left saddled with its debts, all of which he afterward most honorably discharged.

We say Brook Farm failed "of course," and this for the very simple reason that ideal states of society implying natures of a high grade can not be suddenly manufactured out of materials long shaped and adapted to a lower social condition. The adventurers of Brook Farm were sentimentalists, enthusiasts, and philanthropists, amiable and earnest, but of the literary type which implies a highly cultivated ignorance of all the natural laws by which terrestrial affairs are governed. If George Ripley had studied natural things when in college for half the time, and got some tolerable idea of the limitations of human nature under inexorable natural ordinances, he would not have

plunged into so crude and futile an experiment as that at Brook Farm. Of course, it was a generous and noble, an heroic and a chivalric endeavor, and creditable to the hearts of those who turned their backs upon a selfish and sordid civilization to achieve a more harmonious and elevated life; but it was discreditable to their heads that they had not the intelligence to know that it *must* end just where it *did* end—in hopeless failure. Brook Farm collapsed because it was a project of impracticables whose education had been classical instead of scientific.

With the failure of Brook Farm Mr. Ripley took to the vocation of literature. Tired of making the world over, he resolved to accept it as it is, and make the most of it. His success was small at first, but he was an excellent critic, a fine writer, and an indefatigable worker, and these qualities were sure to win success. His career as a journalist and editor is fully and admirably described by Mr. Frothingham, and is very interesting; but it would be easy to show that the lack of the scientific element in his culture was as much a drawback in his later labors as in those that preceded them.

THE NEW BOTANY. A Lecture on the Best Method of teaching the Science. By W. J. BEAL, M. Sc., Ph. D. Second edition, revised. Philadelphia: C. H. Marot. 1882. Pp. 16. Price, 25 cents.

THERE is no class of persons who need teaching more than teachers. There are a few born educators whose native instinct, if not perverted by bad teaching, prompts them to pursue natural and rational methods for teaching others, but the average teacher teaches as he himself was taught, so that bad methods are propagated and spread indefinitely. The author of the pamphlet before us draws an interesting and life-like picture of the old way of teaching botany, in which the sole end and aim was to memorize the parts of the plant, and then learn its name by the aid of an artificial key, thus obtaining a most formal introduction to the stranger.

The new botany began to appear in this country in 1862, and includes a study of the subjects as set forth by Darwin, Sachs, Lubbock, Bessey, and others. It studies objects before books, and sets the pupil to thinking, investigating, and experimenting for himself. Teaching the new botany properly "is simply giving the thirsty a chance to drink." It also creates a thirst which the study gratifies, but never entirely satisfies. For young pupils object-lessons are very popular for a while, but in most cases the interest soon wears away; there is too much pouring in, and too little worked out by the pupil. They bring forth the combined information of all members of a class, but add little or nothing by way of research. To be really appreciated, a student should earn his facts in the study of biology. The author says: "In the whole course in botany I keep constantly in view how best to prepare students to acquire information for themselves with readiness and accuracy. This is a training for power, and is of far more value than the mere information acquired during a course of study in natural science."

The difficulty in the way of teaching the new botany is a serious, almost a fatal one, namely, it requires *an actual knowledge* of the subject on the part of the teacher; it can not be taught, like history and geography, by text-books; and, in addition, the teacher must have tact as well as knowledge. We have not yet reached the millennium of education, when each science shall be taught only by its true disciples and investigators.

IS CONSUMPTION CONTAGIOUS? AND CAN IT BE TRANSMITTED BY MEANS OF FOOD? By HERBERT C. CLAPP, A. M., M. D. Second edition. Boston: Otis Clapp & Son. 1882. Pp. 187. Price, 75 cents.

THAT a second edition of such a book should be called for within two years after its first appearance is sufficient proof of the interest felt in the subject by the people as well as the profession. The author does not set out to prove that consumption is contagious, but presents the arguments advanced on both sides, with such an array of cases that the reader feels almost convinced that it must be either infectious or contagious. Koch's discovery, which has been made since the first edition, is referred to in the new preface and described in the appendix. That this discovery has an important bearing on the question propounded by Dr. Clapp is evident, and in general is

strongly favorable to an affirmative answer. We need not here enumerate the various other reasons presented on this side of the question, such as the immunity of barbarous races from phthisis until they begin to be associated with the whites, its prevalence in convents, harems, and barracks, the frequency of the disease in wives who have nursed tuberculous husbands, etc. Whether the reader admits that the case is proved, the dictates of reason favor the observance of certain precautions, such as not allowing the same person to remain in too constant attendance on consumptives, nor permitting another to sleep with them, securing the most perfect ventilation possible, and the exercise of great cleanliness with immediate removal and destruction of sputa.

The remainder of the book is devoted to a discussion of the effect of tuberculous food, a subject of no less practical importance than the former. The occurrence of tuberculosis among cows and oxen being quite frequent, it is important that every possible means be employed to prevent the consumption of such beef by human beings. Milk from cows affected by this disease is even more to be feared, owing to the difficulty of preventing its sale, and the fact that the greater part of it is consumed without cooking. In addition to this we must consider that milk frequently forms the entire food of young children, and is an important article of diet with invalids, both of whom are more liable to attacks of any new disease than are older and more healthy persons. Aside from the dangerous infective properties, such milk is objectionable as an article of food, owing to its deficiency in fat, sugar, and the nitrogenous elements. The only remedy against these dangers from beef and milk is to be found in a careful, *honest* governmental inspection of all the meat that comes into our markets, especially at the slaughter-houses, and of the cows that furnish our milk, with particular reference to the existence of this disease. It may be a difficult and expensive undertaking, but, for our safety, it must be done.

The book, on the whole, is not intended to quiet the fears of nervous people, or to convince the timid that there is little to be feared from the dreaded scourge—consumption.

THE SUN. By Professor C. A. YOUNG. New edition.

WE are glad to see a new and carefully revised edition of this admirable and standard work, and also that successive editions are called for abroad. Great pains have been taken by the author to give the highest accuracy to the text, and he has appended, in the form of notes, all the new and important information that has accumulated since the first issue. None of these additions discredit what may be regarded as established facts and principles relating to the sun, but they constitute interesting extensions of solar knowledge, together with new and ingenious speculations, the value of which time alone can determine. Professor Young has done well in thus keeping his book sharply up to the time, by which it will maintain its leading position in astronomical literature.

LA NAVIGATION ÉLECTRIQUE (Electric Navigation). By GEORGES DARY. Paris: J. Baudry. Pp. 65, with 17 Illustrations in the text.

THE first part of this work gives the history of the attempts to apply electrical force to the propulsion of boats and airships, including the first essay by M. de Jacobi in Russia in 1839, and the experiment of M. Trouvé, which received the applause due to an apparent success at the Paris Exposition of Electricity last year. A controllable balloon proposed by M. Tissandier, and the electro-motor which he would apply to its propulsion, are also mentioned. The second part of the work embraces a full and detailed description of M. Trouvé's electrical motor, its application, and the degrees of speed attained with it. The whole is hopeful for the ultimate success of electro-navigation.

ANNUAL REPORT OF THE BOARD OF REGENTS OF THE SMITHSONIAN INSTITUTION FOR 1880. Washington: Government Printing-Office. Pp. 772.

THIS report, though tardy in appearing, has a permanent value that justifies a notice of it at any time. The record of work done is very full in notices of explorations and special investigations in which the Institution has had a part; the list of acqui-

sitions to the collections and of exchanges is quite large. The "Record of Scientific Progress," which forms one of the appendices, is designed to take the place in part of the "Annual Record of Science and Industry," formerly published by Harper & Brothers, and contains reviews in astronomy, by Professor Edward S. Holden; geology, by George W. Hawes, Ph. D.; physics and chemistry, by Professor George F. Barker; mineralogy, by George W. Hawes, Ph. D.; botany, by Professor William G. Farlow; zoölogy, by Theodore Gill; and anthropology, by Otis T. Mason. Other important articles in the appendix are "Abstracts of the Smithsonian Correspondence relative to Aboriginal Remains in the United States," a description of the Luray Cavern, Virginia; a discussion of the barometric observations of Professor Snell, of Amherst College; an account of investigations relative to illuminating materials, by Professor Joseph Henry; a bibliography of Herschel's writings; and reports of astronomical observatories.

THE PEAKS IN DARIEN, WITH SOME OTHER INQUIRIES TOUCHING CONCERNS OF THE SOUL AND THE BODY. An Octave of Essays. By FRANCES POWER COBBE. Boston: George H. Ellis. Pp. 303. Price, $1.50.

THE first of the essays in this book, "Magnanimous Atheism," affirms the inefficiency of that creed of agnosticism, or of Comtism, to frame a rule for moral guidance; the second, "Hygeiolatry," disputes the doctrine that bodily health is the chief good "for which personal freedom, courage, humanity, and purity, ought all to be sacrificed," and argues that there are numbers of instances in which disregard of life and health is proper and even a duty. Coming to particulars, it attacks the English laws for the regulation of vice. Another essay, on "Zoöphily," is a vigorous but one-sided protest against vivisection. In other papers, Schopenhauer and his pessimism are assailed, and the fitness of women for the ministry of religion is discussed. The essay which gives the title to the book cites a number of instances of cases wherein, in the opinion of the author, "indications seem to have been given of the perception by the dying of the blessed presences revealed to them, even as the veil of the flesh has dropped away." The papers afford lively reading, but the book is one of opinions and sharp thrusts rather than arguments.

THE FIRE-PROTECTION OF MILLS; AND CONSTRUCTION OF MILL-FLOORS: Containing Tests of Full-Size Wood Mill Columns. By C. J. H. WOODBURY. New York: John Wiley & Sons. 1882. Pp. 196. Illustrated.

THE avowed object of this book is to reduce the risk of fire and its attendant evils, as applied to mills, but many of the precautions are applicable to other structures, and especially to all factories. The first portion is devoted to a consideration of those matters of equipment and general management which experience has proved to be efficient in the fire-protection of mills. Under these we notice some practical suggestions regarding fire-pails, and where and how they should be kept ready for use. The various forms of fire-pumps are described and illustrated, the advantages and disadvantages of each being carefully stated. The next subjects in order are hydrants, stand-pipes, drip-couplings, hose-valves, and nozzles; also a table showing the quantity of water discharged per minute from a one-inch nozzle under pressure of from fifteen to eighty-five pounds per square inch. Several systems of "sprinklers," or perforated pipes, intended for the more hazardous parts of mills, are described. The efficiency of these is often impaired by rust and paint obstructing the orifices. The latter should be guarded against by placing tacks in each hole before the sprinklers are painted; the former by the use of a brass bushing. The automatic sprinkler, the author says, is one of the oldest devices for special fire apparatus, the first patent having been granted in 1806. A large number of automatic sprinklers are figured, full size or half size.

The next subject treated is the causes of mill-fires, among which we find that spontaneous combustion holds a prominent place, second only to friction and foreign substances in the picker. Matches and lighting apparatus, of course, are dangerous elements, as well as lightning, fire-works, and stoves. In one case a freshet caused such a rapid oxidation of iron turnings as to set

fire to the sawdust that was mixed with them.

The advantages of electric lighting for mills are dwelt on at some length, the different systems being described and the cost compared. The latter contains the results actually obtained at the Globe Mills in Woonsocket, where the expense of lighting a weave-room three hundred feet by sixty-six, by gas, was nearly twice the cost of lighting the same room by electricity, gas costing $2.20 per thousand feet. Only one hundred and seventeen incandescent lamps were employed, where two hundred and sixteen gas-burners had been used, making the cost per light very nearly the same. The dangers of electric lighting are admitted, and the precautions to be taken are enumerated.

The second portion of the book treats of the restriction of injury from fire by means of the application of sound principles of building pertaining to slow-burning construction. The features of bad construction and the elements of safe construction are considered, and formulæ are given for the strength of beams, planks, floors, etc.

The book is handsomely printed in large clear type, on good paper, and bound in "fiery red" cloth, which makes it rather suggestive. It is a book that could be read with advantage by many others than builders and owners of mills, and it is to be hoped that its practical suggestions may accomplish what its author aims at—a reduction in the number and extent of mill-fires, with the attendant loss of life and property.

EASY STAR LESSONS. By RICHARD A. PROCTOR. Illustrated with Forty-eight Star Maps and Thirty-five Woodcuts. New York: G. P. Putnam's Sons. 1882. Pp. 219. Price, $2.50.

THE object of this last book of the distinguished astronomer is to teach the star groups, and enable the learner to find them *on the sky*. Instead of the usual star maps that represent the entire visible heavens and require to be held upside down, or sideways, in tracing out the constellations, four maps are given for each month of the year, namely, a northern, a southern, an eastern, and a western map, making forty-eight in all. The maps are printed in blue, the stars in white; the principal stars of each constellation are joined by dotted lines, and the names of the constellation are given, but the usual imaginary pictures of bulls, fishes, and dragons are all omitted, so that the map more nearly resembles the sky than is usual. Lines are drawn to represent the horizons of New Orleans, Louisville, Philadelphia, and Boston; also of London, England. The zenith of each place is likewise given. Several pages of letterpress accompany each set of star maps, and explain the method to be followed in tracing out each group, and woodcuts are employed in the text to exhibit the position of the larger stars as related to the bulls and bears of the sky. This method of separating the real from the imginary will be a boon to the star-gazer and the student, for it is very pleasant to know the stars—to be able, like Milton's hermit, to

> ". . . sit and rightly spell
> Of every star that heaven doth show."

REPORT OF THE COMMISSIONER OF EDUCATION FOR THE YEAR 1880. Washington: Government Printing-Office. Pp. 914.

THE commissioner asserts that the important relation which his department sustains to the interests of education is becoming constantly more apparent; and that the year covered by the present report was marked by a great increase in the amount and value of the information received at the office with reference to the conduct of education in our own and foreign countries, and by a corresponding increase in the public demand for the distribution of information. The department is endeavoring to secure a more exact particularity and definiteness in the educational statistics from the different States, so that they may show more clearly the condition of the schools, the proficiency of the pupils, and the degree of attention that is given to each branch of study. It has succeeded so far that the reports from Ohio give the number of pupils in each of the branches taught, and those of more than a dozen other States give approaches to the result. Advance is claimed in the consideration shown in the arrangement of courses of study to psychological conditions and the necessities of pupil life. An approach has been made in the last ten

years toward uniformity in the general outlines of the school systems of the different States, "which seems remarkable in view of the diversity of educational conditions in the several States prior to 1870, the opposite theories which prevailed in different sections, and the great contrast between the newly settled States and older commonwealths in social conditions and available resources." Information concerning rural schools being given now fuller and in more explicit shape than formerly, their deficiencies and wants are in consequence more clearly perceived, and there is ground for belief that improvement in them will be steady and rapid. Women's opportunities to influence education as voters and school-officers have been greatly enlarged in many States, but the commissioner regrets to say that the women have shown more indifference to them than he had expected. The usual annual review of the different classes and grades of schools in the United States is given, but, while it shows the general improvement in efficiency that was to be expected, reveals nothing new that calls for especial remark. Papers are appended on "Education in Foreign Countries," "Industrial Education," "Popular Science Teaching," "Evening, Army, and Summer Schools," "Myopia," the "Physiology of Reading and of Writing," and other topics bearing upon the advancement and improvement of education.

MANUAL OF BLOW-PIPE ANALYSIS, QUALITATIVE AND QUANTITATIVE, WITH A COMPLETE SYSTEM OF DETERMINATIVE MINERALOGY. By H. B. CORNWALL, Professor of Analytical Chemistry and Mineralogy in the John C. Green School of Science, Princeton, N. J. New York: D. Van Nostrand, 1882. Pp. 308.

THE title of the book before us very fully explains its nature and purpose. Professor Cornwall's skill as a chemist and experience as a teacher peculiarly fit him for the preparation of a manual that shall supply the student with all the needed information for pursuing a complete course in blow-pipe analysis.

The work is similar in plan, but wider even in scope, than Plattner's well-known manual, which was translated by Professor Cornwall in 1872, and has since been the standard text-book. In the present work, many details have been added which tend to lessen the labors of the instructor, and adapt the book to the use of students who are working alone, although it will be readily understood that few persons will be able to acquire skill in a branch requiring such delicacy of manipulation without personal instruction. The apparatus and operations are first fully described and carefully illustrated by numerous woodcuts; special tests are then given for each of the elements, including even the rare metals, for in blow-pipe analysis it frequently happens that the presence of only one or two substances is to be sought, and it is then unnecessary to go through a complete analysis. The fourth chapter, however, contains special schemes for complex substances, and methods for the examination of metallurgical products and paints; also Professor Egleston's scheme for complete analysis, as it appeared in the author's translation of Plattner. The system has been devised with the view of employing the blow-pipe to the exclusion, as far as possible, of wet methods, but a few directions are given for the general operations in wet analysis, and a list of reagents both solid and liquid required for the latter. Mention is made of the use of citric acid, as recommended by Professor H. C. Bolton, for decomposing minerals; also of the glycerine test for boracic acid. We can not help feeling that the addition of a list of Bunsen's "flame reactions" would have added to the value and completeness of the book. The use of spectrum analysis is very briefly described, and an (uncolored) lithographic plate shows the position of the lines and bands which characterize the metals usually sought for in this way.

In the chapter on quantitative analysis, the method of assaying gold, silver, copper, lead, bismuth, tin, mercury, and cobalt and nickel ores is fully described, and the apparatus employed are illustrated. In this sort of work the automatic apparatus, described on pages 180, 181, are very convenient, as a long-continued and steady blast is essential. As the quantity of ore that can be assayed is very small, the operations of quantitative blow-piping are very delicate, and an exceedingly accurate balance is an absolute necessity.

It is well adapted to the assay of alloys, but when ores are to be assayed very great care is required to obtain a fair sample in so small a quantity of material. With these drawbacks, blow-pipe analysis offers many advantages over wet analysis, as it requires no special laboratory, and the apparatus are much more portable.

Chapter VIII contains a description of the important ores and coal, and the last chapter is devoted to determinative mineralogy. In this chapter, the minerals, like plants in a botanical key, are subjected to an artificial classification depending on certain external properties. The classes are then subdivided according to their reaction before the blow-pipe, such as fusibility, odor, or coat on charcoal. The method of writing the mineral formulas is that followed by Plattner and Kobell.

Professor Cornwall's book is, on the whole, so complete and practical, that it will soon take the place of the larger and more expensive manual of Plattner in our leading scientific schools.

CATALOGUE OF 1,098 STANDARD CLOCK AND ZODIACAL STARS. Prepared under the direction of SIMON NEWCOMB. Pp. 314.

THIS catalogue was commenced at the Naval Observatory for the purpose of obtaining standard positions of reference stars for use in the lunar and planetary theories, especially in the reduction of the older occultations. In 1877 the unfinished work was turned over to the office of the American Ephemeris, and has been completed by Chauncey Thomas, U. S. N., under the personal direction of Professor Newcomb.

PUBLICATIONS RECEIVED.

A Guide to Modern English History. By William Cory. Part II. 1830–'35. New York: Henry Holt & Co. Pp. 567.

History of the Pacific States of North America. By Hubert Howe Bancroft. Vol. I. Central America. San Francisco: A. L. Bancroft & Co. Pp. 704.

Practical Life and the Study of Man. By J. Wilson, Ph. D. Newark, New York: J. Wilson & Son. Pp. 400. $1.50.

The American Citizen's Manual. Part I. Governments, the Electorate, the Civil Service. Edited by Worthington C. Ford. New York: G. P. Putnam's Sons. Pp. 146. $1.

Speech and its Defects. Considered Physiologically, Pathologically, Historically, and Remedially. By Samuel O. L. Potter, M. A., M. D. Philadelphia: P. Blakiston, Son & Co. Pp. 117. $1.

How to Succeed. A Series of Essays by Various Authors. Edited, with an Introduction, by the Rev. Lyman Abbott, D. D. New York: G. P. Putnam's Sons. Pp. 131. 50 cents.

Schelling's Transcendental Idealism. A Critical Exposition. By John Watson, LL. D., F. R. S. C. Chicago: S. C. Griggs & Co. Pp. 251. $1.25.

Swift. By Leslie Stephen. New York: Harper & Brothers. Pp. 205. 75 cents.

Sterne. By H. D. Traill. New York: Harper & Brothers. Pp. 173. 75 cents.

Hints for Sketching in Water-Color from Nature. By Thomas Hatton. Edited by Susan N. Carter. New York: G. P. Putnam's Sons. Pp. 69. 50 cents.

Drawing in Black and White. Charcoal, Pencil, Crayon, and Pen-and-Ink. By Mrs. Susan N. Carter. New York: G. P. Putnam's Sons. Pp. 55. 50 cents.

Potable Water and the Relative Efficiency of Different Methods of detecting Impurities. By Charles Watson Folkard. New York: D. Van Nostrand. Pp. 138. 50 cents.

In Memoriam. Benjamin B. Redding. San Francisco: California Academy of Sciences. Pp. 18.

Is Tubercular Consumption a Contagious and Parasitic Disease? By Bela W. Cogshall, M. D., of Flint, Michigan. Pp. 12.

On Nocturnal Epilepsy, and its Relations to Somnambulism. By M. G. Echeverria, M. D. Lewes: "Sussex Advertiser" Office. Pp. 32.

Forestry Bulletins of the Census Office, 18 to 22.

A Plan for securing Observations of the Variable Stars. By Edward C. Pickering. Cambridge: John Wilson & Son. Pp. 15.

An Evolution Aspect of the Healing of Wounds, with Deductions as to Treatment. By C. Pitfield Mitchell, M. R. C. S., 30 E. 35th Street, New York. Pp. 13.

The Pathology and Philosophy of Sea-Sickness. By C. Pitfield Mitchell, M. R. C. S., 30 E. 35th Street, New York. Pp. 16.

Subscales, including Verniers. By Henry H. Ludlow, U. S. A. New York: D. Van Nostrand. Pp. 16.

On the Prevention of Fires in Theatres. By C. John Hexamer. Philadelphia: "Merribew" Print. Pp. 18.

Some Points on the Administration of Anæsthetics. By George H. Rohé, M. D. Baltimore: Office of the "Medical Chronicle." Pp. 18.

Use of the Ecraseur for curing Deep-Seated Fistula-in-Ano. By J. M. F. Gaston, M. D., of Campinas, Brazil. Pp. 8.

Report of the Bureau of Statistics relative to the Imports, Exports, Immigration, and Navigation of the United States for the Year ended June 30, 1882. Washington: Government Printing-Office. Pp. 112.

Analyses of Beethoven's First and Second Symphonies. By George Grove, D. C. L. Boston: George H. Ellis. Pp. 16 each. 15 cents each.

Address delivered by the President of the Homœopathic Medical Society of Pennsylvania, September 5, 1882. By John C. Morgan, M. D. Pittsburg: Stevenson & Foster. Pp. 13.

Radiant Heat an Exception to the Second Law of Thermo-dynamics. By H. T. Eddy, Ph. D. Cincinnati. Pp. 12.

"The American Journal of Physiology." Edited by D. H. Fernandes, M. D. Vol. I, No. I. Indianapolis, Indiana. Pp. 8.

The Gulf Stream. Additional Data from the Investigations of the Coast and Geodetic Steamer Blake. By Commander J. R. Bartlett, U. S. N. Pp. 16. With Map.

Phonetics of the Kayowe Language. By Albert S. Gatschett. Pp. 6.

A Dictionary of Music and Musicians. Edited by George Grove, D. C. L. Parts XV and XVI. London and New York: Macmillan & Co. Pp. 272. $2.

Sanitary Tracts. Issued by the Citizens' Sanitary Society of Brooklyn. Pp. 12. 5 cents.

Ottawa Field-Naturalists' Club. Transactions No. 3. Ottawa, Canada: Citizens' Printing and Publishing Company. Pp. 66. With Two Plates.

The Practice of Gynæcology in Ancient Times. By Edward W. Jenks, M. D., LL. D. Chicago, Illinois. Pp. 46. With Two Plates.

Statistics in Relation to Gold and Silver. Compiled by E. J. Farmer. Cleveland, Ohio. Pp. 37. 25 cents.

The Analogy between Sound and Color. By G. G. Finn. Cleveland, Ohio. Pp. 22.

The Muscles of the Limbs of the Raccoon. By Harrison Allen, M. D. Pp. 30.

Tornadoes. Their Special Characteristics and Dangers. With Practical Directions for Protection of Life and Property. By John P. Finley. Kansas City, Missouri; Ramsay, Millett & Hudson. Pp. 29.

Tornado Studies for 1882. By John P. Finley. Kansas City, Missouri: Ramsay, Millett & Hudson. Pp. 14.

Notes on Physiological Optics. By W. Le Conte Stevens. Pp. 8.

Unscientific Materialism. A Criticism of Tyndall's "Fragments of Science." Fifth edition. By S. H. Wilder. New York. Pp. 16.

A New View of our Weather System. By Isaac P. Noyes. New York: Fowler & Wells. Pp. 51. 25 cents.

POPULAR MISCELLANY.

The Flora of North America.—Professor Asa Gray gave an historical account, at the last meeting of the American Association, of the study and compilation of the North American flora. The first "Flora" of the country was published by Michaux, in 1803. It embraced plants representing the whole region from Hudson Bay to Florida, and contained 1,530 species. The work of Pursh followed about twenty years afterward, and represented a much smaller territory, not extending west of Virginia or north of Lake Champlain, but contained 740 genera and 3,700 species. Dr. Gray himself started on his great botanical work in 1830, while he was an assistant in a doctor's office in New York. It is not exactly known when Dr. John Torrey conceived the idea of publishing a third "Flora of North America," but he invited Nuttall to join him in the work as early as 1832. Arrangements were afterward made with Dr. Gray, and the first volume of the conjoint work was issued in 1838. It was generally thought that the orders remaining to be described could be soon worked out, and the "Flora" completed, but the rapid publication which the fulfillment of such an anticipation required was not possible. Dr. Torrey had already been to Europe and spent a considerable time in the study of foreign herbaria. Dr. Gray also visited Europe at the end of 1838, and spent several months in the same work, paying especial attention to the American herbaria of Michaux, Pursh, De Candolle, and others. A second volume of 500 pages appeared in 1840, and carried the "Flora" to the end of the *Compositæ*. The work was then interrupted by the pressure of other duties, so that the third volume was not added to the series till 1880. The labor of pushing the work to completion is very difficult now compared with what Pursh endured when the species were fewer and the number of specimens collected of each was many times less. The first volume of the present "Flora" contained about twice as many species as Pursh gave for the same orders; and the number of species in these families has increased greatly in the thirty years since its publication. American flowering plants can not now be represented with less than 10,000 species, and the number is increasing daily, so that soon 12,000 may be required. The amount of material collected is vast; additions are constantly pouring into the Harvard herbarium, and the time of the compilers is severely taxed to work it over. The work in the future must be divided up among many persons, each doing a part; and Dr. Gray earnestly solicits the co-operation of all botanists.

The Proposed Geological Map of Europe.—The International Geological Congress, which met at Bologna last year, decided upon the preparation of a geological map of Europe, which should exemplify a uniform terminology and a uniform system of coloring, and appointed an International Committee to superintend the work. The execution of the map will, of course, require many years, but its general plan and the regulations under which it is to be carried on have been already provisionally agreed upon. The map is to be published at Berlin, under the immediate direction of Messrs. Beyrich and Hauchecorne, of the

Royal Prussian Geological Institute. The data from each nation will be furnished through its representative on the International Committee, if it has one; or, if it is a small state, and is not thus represented, by its vice-presidents in the Congress. The map will include the whole basin of the Mediterranean and all of Europe to the eastern slope of the Ural Mountains, and will be made upon a scale of 1 to 1,500,000. It will therefore cover a space of 372 by 336 centimetres, or about twelve by eleven feet, and will, for convenience of use and binding, be divided into forty-nine sections of about twenty-two by sixteen inches each. The primary object of the map will be to give a clear representation of geological conditions. It will not be practicable consistently with this to give particular attention to orographical details. The river systems, the principal towns, the more important mountain-ranges, and the curves indicating sea-depths, will be denoted so far as seems fitting. The topographical basis of the map is to be reconstructed on the proposed scale under the supervision of Professor H. Kiepert, of Berlin. The total expense of the work is estimated at 80,000 marks, or in the neighborhood of $20,000, and is to be borne by the states interested, the eight largest states contributing each one ninth, and the smaller states together the other ninth, of the whole. The subscription price for the first edition will be 80 marks, or about $20, a copy of the whole map. The price will afterward be raised to 100 marks, or $25.

Origin of Petroleum.—The Huron and Cleveland (Devonian) black shales of Ohio contain from 2 to 22 per cent of organic matter, which Dr. Newberry regards as of marine origin, and are the source of some of the petroleum-wells. Decomposition has been carried on so far that all structure seems to have been obliterated; but Dr. Orton stated, in a paper read before the American Association, that he had discovered the organic substance to consist of sporangia or spore-cases of *Lycopodiaceæ*. He had found numerous resinous disks of from $\frac{1}{100}$ to $\frac{1}{75}$ of an inch in diameter, translucent, amber-colored, appearing as a rusty crust, with ridged and furrowed surfaces, burning freely, insoluble in alcohol, and sometimes having stem-like attachments. Different beds afford disks of different sizes. The Pennsylvania and New York petroleum-wells originate in the equivalent of the Ohio black shales.

A Medal to Pasteur.—A medal commemorative of his remarkable discoveries was presented to M. Pasteur at the sitting of the French Academy of Sciences, June 26th, by M. Dumas, on behalf of a committee of scientific men and friends and admirers of the distinguished investigator. M. Dumas reviewed briefly the great services M. Pasteur had rendered to science, art, and industry, through his researches among the vital organisms of fermentation, and closed by saying: "My dear Pasteur, your life has only known successes. The scientific method, of which you make certain use, owes you its finest triumphs. The Normal School is proud to count you among the number of its students; the Academy of Sciences is elated at your researches; France ranks you among her glories. . . . Science, agriculture, industry, humanity, will feel eternal gratitude to you, and your name will live in their annals among the most illustrious and the most venerated." Pasteur replied modestly, acknowledging his obligations to his teachers, and said: "Hitherto great eulogies have inflamed my ardor, and only inspired the idea of rendering myself worthy of them by new efforts; but those which you have addressed to me, in the name of the Academy and of learned societies, truly overpower me."

Were the Mound-Builders Indians?—Dr. Hoy read a paper at the American Association in support of the view that the mound-builders were the ancestors of our present Indian race. He held that the age of the mounds had been exaggerated. The growth of large trees upon them is not certain evidence of great age, for some trees grow very fast. It was also a mistake to suppose that the mound-builders could be distinguished from Indians by their being an agricultural people. The Indians have largely tilled the ground. De Soto lived with his army four years among the Indians of the South, and quartered his two hun-

dred and eleven horses for forty days in one spot. The absence of traditions about the mound-builders can not be regarded as evidence of separate origin; it is a fact that the Winnebagoes and Menomonees have no traditions going as far back as to Marquette, or even to John Carver, not a century ago; and, in truth, their traditions are so short that they deny that the Indians ever used stone arrow-heads. The author concluded that there was abundant evidence of an Indian origin in the mounds—including the finding of European implements in them that must have been placed there when they were made—from the Gulf of Mexico to Northern Wisconsin.

Dr. Hoy also discussed the question of the origin of the copper implements that are found in the neighborhood of Lake Superior. He remarked that the explorers of the St. Lawrence, Lake Superior, and the Eastern coast, all say that the Indians had these implements, and that the copper-mines of Lake Superior show no evidences of great antiquity. The Chippewas and Winnebagoes both have copper ornaments. Professor Butler has a copper spear-head, plowed up in Wisconsin, containing part of an iron rivet, which had doubtless been made or used after the Indians had traded with the whites, and had had access to iron. The author was of the opinion that the Indians of the Lake Superior district made copper implements for themselves, and also for extensive barter, and did not see how any reasonable man could assert that the Indians knew nothing about the use of the native metal. Professor Putnam discussed the same subject in his paper on the North American copper implements and ornaments under his charge in the Peabody Museum. He had no doubt that the Indians used copper, and that its use was contemporary with that of polished stone implements. The native copper was hammered, not molded, into shape; and the speaker described the way in which the processes were carried out. Some ornaments that had been connected with Christianity were really only shaped as they were easiest to make. Some classical-looking ear-rings were shown, which had been made from native copper beaten out.

Formation of Prairies.—Mr. H. D. Valin, of Chicago, has proposed a new theory to account for the formation of prairies and the elevation of the country west of the Mississippi. Noticing that the prairies rest generally on Silurian rocks, he believes that they represent ground which has always been inundated, or subject to periodical overflows. The waters, when high, washed away the rocks of the bluffs, and deposited on the level surface beneath them the clay resulting from the erosion; while the *detritus* forming the sod of the prairie dates always from the last inundation. The constant exposure of the prairie-soil to submersion accounts for the absence of trees. The land has risen partly by deposition, but in large part also because of the elasticity of the earth's surface, "which, like matter in general, always tends toward an equilibrium. For instance, the highest mountains weigh about the same on the surface of the earth that the deepest ocean does, otherwise their respective levels would come into one. Now, as the *detritus* of the rocks is carried by streams into the sea, the porous material grows heavier, though not increased in size, and the equilibrium is forcibly reestablished by a slow upheaval of the land. The pressure exerted laterally by such upheaval is, likely, the origin of volcanoes, geysers, and earthquakes."

Physiological Analogies of the Roman Letters.—Professor A. Melville Bell, in explaining the system of "visible speech" at the late meeting of the American Association, remarked that something like a physiological principle may be found to pervade our Roman alphabet. The actions of the lips, the most obvious of the speech-organs, would naturally be the most definitely indicated; and it is among the labial letters that we find the most numerous illustrations of an apparently physiological basis. The rounded form of the lips in pronouncing O is, for example, very suggestive of the circle, which is the emblem of that element; and in the letter B we have a perfect representation of the profile of the closed lips. The letter P as compared with B, seems to suggest a sound of similar organic production, but lacking something of the B sound —and this is the exact physiological relation

of the elements. B and P are alike, excepting that B has a vocal murmur, which is wanting in P. The letters P and F present another instance of physiological consistency, the closed part of P being opened in F, as if to indicate a sound of similar formation without obstruction of the breath. The letter C exhibits the outline of the back of the tongue in pronouncing the hard sound of the letter, and the kindred letter G consistently shows an element of similar formation, but with the addition of something that is lacking in C. The letter K, a duplicate for the sound of C hard, consists of a C, angular instead of rounded, in contact with a posterior line, and thus very suggestively denotes the action of the tongue against the roof of the mouth. The letter T, in the same way, appears to denote the position of the tongue in pronouncing the sound; the roof of the mouth being denoted by the horizontal line, while the vertical line shows the upward direction of the tongue to contact with the palate.

Antiquity of Man in America.—"The Geological Testimony to the Antiquity of Man in America" was considered by Professor Willis De Hass, in a carefully prepared paper which he read at the American Association. After referring to a skeleton disinterred at Natchez, Mississippi, of very uncertain antiquity, and the remains yielded by the Trenton gravel formation, which he was disposed to place at even a pre-glacial period, the speaker mentioned the caverns as constituting the best sources of information as to human antiquities. They show evidences of an existence of man on this continent long antedating the mound period, and would, he had no doubt, hereafter become as celebrated for human antiquities as were the caverns of Belgium and France. He attributed the ancient copper-workings of Lake Superior to a prehistoric race, and asserted that a greater amount of labor had been performed by its miners in a space of less than two thousand acres than two thousand men working twenty years could perform in our time. All the mines of the Lake Superior region, he added, gave evidence of having been wrought by a prehistoric race. Professor De Hass did not, however, consider that the mounds and mural works of the West and South bore evidence of a high antiquity—or of more, perhaps, than two thousand years. They might be assigned to a people intermediate between the mound-builders and the Indians.

Ancient Cults among the Berbers of Morocco.—Dr. Haliburton, of Ontario, has taken advantage of a recent sojourn in Morocco to study the vestiges of ancient cults of Europe and Asia which are still preserved among the Berber tribes. Here he found the crude stories of the twelve labors of Hercules, of Apollo, of Minerva, of Isis and Osiris, of Belus and Astarte. Numerous observations indicated that here, too, must have been the home of the myth of Saturn and of the golden apples of the Hesperides. A very interesting part of the paper on this subject communicated to the American Association by Dr. Haliburton was the mention of many names and stories connecting these people with the Bible, such as those of the gold of Ophir, the Queen of Sheba, the land of Havilah, and of the vessels of beaten gold and silver in the temples. On the last point the speaker dwelt at length, presenting numerous brass and silver works and jewelry, made by the Shillooks in our own day. The fables of Atlas and the Atlantes were traced in the very cradle of the people themselves. The fable of the head of Medusa was traced to this place in accordance with the story of Herodotus, that it arose from the custom of the people of a certain region wearing leather trappings on their heads. Dr. Haliburton showed a leather ornament of a powder-horn with a fringed leather border, like that on a Sioux saddle-ornament, and similar to those described by Herodotus. The whole paper was full of allusions to classic mythology and Biblical story.

The American Indians and the Aryan Race.—"Have the Indians come from Europe?" was the subject of a paper read by Horatio Hale, of Clinton, Ontario, at the recent meeting of the American Association. After tracing the course of emigration of the leading stocks of the Indian tribes, as indicated by their languages, and the modifications they seemed to have undergone, the author remarked that the fact that the

course of emigration seems to have been from the Atlantic coast toward the interior might be regarded as evidence that the ancestors of our Indian tribes were emigrants from Europe. Reference was made, in support of this view, to the close resemblance in structure between the Basque and the Indian languages. It was suggested, also, that if the Aryan intruders, entering Europe from the East, encountered and absorbed a population resembling the American aborigines, the fact would account for the great change which the Aryan speech underwent in Central and Western Europe. It would also account for the remarkable change which took place in the character of the intruding race. The Aryans, who in the East have always been a submissive and contemplative race, devoid of the idea of popular government, became, in Europe, a high-spirited, practical, and liberty-loving people. Mr. Hale concluded that the natives of modern Europe were a people of mixed race, forming a transition, in physical and mental traits, between the Eastern Aryans and the aboriginal Americans.

Wine from Beets.—Induced by the havoc wrought among the French vines by the phylloxera, the Messrs. Brin, of Paris, have patented processes for making red and white wines from red and white beets. The roots may be used raw, but it has been found preferable to cook them. Perfectly sweet and clean roots are chosen, and after being cooked are reduced to a pulp. The juice is then pressed out and strained, and put into vessels of wood or cement, but not of metal, with a certain quantity of water, if desired, to ferment. This process is aided by admitting steam or hot water through serpentine coils placed in the receivers, and adding some of the ordinary ferments, and alcohol, according to the degree of strength that is wanted. After fermentation the whole is strained with tannin. The wine obtained by this process is said to possess all the properties of wine from grapes, and is treated henceforth like grape-wine. It is well adapted, by virtue of its saccharifierous qualities, to improve wines poor in sugar and rich in tannin. The red wine, moreover, is good for adding color to other wines that need it. The white wine is supposed to be improved by the addition of a little nitric acid at the moment of fermentation, after which the whole is "well shaken."

Analogies of Ancient Old World and American Customs.—Dr. Phené called attention in the American Association to some hitherto unnoticed affinities between ancient customs in America and other continents. He mentioned customs which have been shown to have existed in the great river-valleys of our countries or have been revealed in the mounds, that had parallels in various European and Asiatic countries. Among them were those indicated by the occurrence of figures of serpents, alligators, or mythical dragons, and the human form, the characteristic features of which were curiously persistent in each case. Some of the shapes of the semi-barbaric age of Mexico corresponded with forms in Devonshire and South Wales. In the vicinity of some such figures of this character in the west and east of the south of England were enormous intaglio representations of the human form corresponding to the intaglio forms at Milwaukee, Wisconsin. Drawing attention to several other apparent correspondences, the speaker said that they were the result of a practice and culture transmitted with concurrent customs by way of the Pacific from one continent to another.

Russian Geological Research.—The mining department of the Russian Government has founded a geological institute for the purpose of centralizing all geological research in Russia, and preparing a detailed geological map of the empire. The empire has been explored geologically in a general fashion by several men of science, who have given accounts of observations, the most complete of which is that of the English geologist Murchison. This is still a classic work, and all recent geological maps of Russia are only improved editions of the one prepared by him. A continuous series of geological expeditions, which have considerably advanced the knowledge of Russian geology, have been conducted by the mining department and private scientific societies in connection with the universities; but all these researches have wanted the system and connection which can be given

them only by referring them to some central organization and direction like the newly established institute.

Action of Citric Acid on Minerals.—Professor H. C. Bolton read a third paper at the recent meeting of the American Association on the decomposition of minerals by citric acid, detailing the results of his later researches on the subject. Some of the conclusions expressed in the first of his two previous papers were modified in the second paper, in view of the results obtained by the prolonged action of the acid. In the third series of experiments Professor Bolton found that many species which resist the brief action of a boiling concentrated solution of citric acid are more or less completely decomposed by prolonged contact with the same solution at the ordinary temperature of the work-room. He has drawn up a table, in accordance with the last series of tests, of thirty-two minerals or classes of minerals which are classified as those that are quickly, slowly, very slowly, or not, decomposed by citric acid.

In an American Association paper Dr. Britton describes a Post-Tertiary, pre-glacial deposit, near Bridgeton, New Jersey, compact enough to furnish a building material, which contains casts of the shells of the hard clam, with silicified wood, and in which very fine impressions of leaves—including those of the sweet-gum, or liquidambar, viburnum, zizania, and elm—are occasionally found.

NOTES.

According to the Census Bureau's bulletin of the statistics of the lumbering industry of the United States for the year ending with May last, $181,186,122 are invested in 25,708 establishments for the preparation of lumber, and the total value of the products for the year was $233,367,729. Michigan leads the States in this industry with 1,649 mills, $39,260,428 capital, and $52,449,928 of products. Pennsylvania is second, with 2,827 mills, $21,418,588 of capital, and $22,457,359 of products. Next are Wisconsin, with $19,824,059 of capital, and $17,952,347 of products; New York, $13,230,934 of capital, and $14,356,910 of products; and Indiana, with $7,048,088 of capital, and $14,260,830 of products. Maine, which used to be considered emphatically the "lumber State," is now seventh in rank, having 848 mills, with $6,339,396 of capital, and $7,933,868 of products.

Dr. Desiré Charles Van Monkhoven, who died on the 25th of September last, just forty-eight years old, was at once distinguished as an astronomer, a chemist, an optician, and a photo-chemist, and was also an active and capable man of business. He was best known by his researches in optical questions bearing on photography, and particularly by his practical applications of them in the Monkhoven solar enlarging apparatus, the Monkhoven tissue for carbon printing, and the Monkhoven gelatine plates, which he invented, and of which he directed the manufacture. He was the author of a general treatise on photography and of papers on his spectral and other researches, contributed to various periodicals.

On the 22d day of April, and on rainy days afterward, the water in some parts of the city of Lille became unfit for use. M. Géard, investigating, found the cause of the trouble to be the growth of a mucidine of the genus *Cremotryx*, which, greedily absorbing iron, produces in the pipes masses of ochreous matter, the putrefaction of which disengages sulphureted hydrogen in considerable abundance.

A venomous lizard has been presented to the Zoölogical Gardens of London by Sir John Lubbock. It is called *Heloderma horridum*, or horrid warty-skin; it is from Mexico, and is described as about "one foot and a half in length, of a somewhat thickish form, and with a rather short, pointed tail. Except in color its aspect is not prepossessing." It is of a pale ochre, or corn-color, coarsely reticulated with black marks. All of its teeth are connected with poison-glands.

Mr. W. O. Crosby, of Boston, proposes to account for the origin of the seams running in three directions, by which many rocks are cut up into rectangular blocks, as from earthquake-action. Professor H. F. Walling, of Washington, agrees with him. When the papers of these gentlemen were read in the American Association, Professor Newberry, having expressed a sense of obligation to the authors for bringing the subject forward, said that he was inclined to think magnetic currents may have had some part in the production of the joints. Professor Hall called attention to the joints in the clays at Albany, which could not well have been subjected to pressure.

A correspondent of the London "Daily News" states that some interesting objects have recently been found in Neufchâtel which are considered by Swiss archæologists to throw a new light on the history of the lake-dwellers. Among the objects are a carriage-wheel with an iron rim, iron swords, and many human bones.

HENRY DRAPER.